



CENTRAL FORECASTING TECHNICAL NOTE NO.22

A TRIAL OF A NEW TECHNIQUE FOR THE BOGUSSING OF
TROPICAL CYCLONES

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OCTOBER 1994

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1. INTRODUCTION

Recent developments in global numerical weather prediction (NWP) models have resulted in a growing interest by many national meteorological centres in the forecast of tropical cyclones (TCs) since these models frequently show skill over climatology/persistence (CLIPER) methods (Fiorino et al., 1993). The UK Meteorological Office (UKMO) numbers itself amongst these centres and over recent years has increased its effort in the areas of TC forecast improvement and verification, dissemination and international profile of products.

The UKMO NWP global model currently operates on a horizontal grid of 139km x 93km at the equator and has 19 levels in the vertical (Cullen, 1993). Hall (1992) found that this model showed some skill in the forecast of TC genesis in a study of the western North Pacific basin in 1991. However, even when a tropical storm has developed, the model's analysis of the system may be poor due to the sparsity of observations in many parts of the tropical oceans. This can inevitably lead to large forecast errors. Consequently, the UKMO uses "bogus" observations created by the forecaster to define the storm's location and structure in the model.

In this paper "Tropical Cyclone" (TC) is taken to mean any tropical storm with maximum sustained wind of greater than 30 knots.

A Summary of Current Bogus Techniques

The Intervention Forecaster (IF) in the Central Forecasting Office (CFO) is able to perform manual quality control of observations prior to them being presented to the model. In addition he is also able to create individual bogus observations (mean sea-level pressure (MSLP), temperatures, winds, relative humidity (RH) and 500-1000mb thickness) for use in the model. The IF is able to insert individual bogus observations in the vicinity of TCs, but will usually use one of two techniques which considerably reduce the effort involved.

i) The main TC bogus technique enables the IF to create four bogus points on a circle of 2.5° radius around the storm. Bogus MSLP and wind observations at 850mb, 700mb and 500mb are always created and until April 1994 there also existed an option to bogus RH. See Hall et al. (1992) for further details.

ii) There also exists a technique to reposition a low pressure system already established in the model, but wrongly located. This technique is available for mid-latitude as well as tropical depressions and is used less frequently than i) above. See Hall et al. (1992) and Heming (1992) for further details.

Information as to the location and strength of storms, which is used as the basis for all bogussing, is taken from real time advisories received from Guam, Miami and other TC warning centres.

In a 17-day trial of the impact of all types of intervention (including TC bogussing), which took place in October 1992, it was found that current bogussing techniques reduced TC analysis errors by 58% and forecast errors up to T+48 by 29% when compared to forecasts where no bogus observations were used (Heming, 1993). There were ten active TCs during this trial period. Hence, the use of these current techniques as opposed to leaving the model alone was clearly justified.

2. A NEW TROPICAL CYCLONE BOGUSSING TECHNIQUE

Despite results indicating that current bogussing techniques are better than nothing at all, it is recognised that the main TC bogussing technique is a fairly simplistic method which involves imposing a symmetric circulation on a storm which in reality may exhibit some asymmetry in its structure. This could potentially affect the steering of the storm in the model and indeed it has been noted over recent years during the course of routine verification that the model has a polewards bias in its steering of many TCs. Two examples of this are forecasts for TC Yancy in 1990 (Heming, 1990(a)) and more recently TC Koryn in 1993 (Figure 1). It was conjectured by Pathack (1994) that this poleward bias and the occasional over-intensification of storms in the model may also be as a result of the use of RH bogus which is optional in the current bogussing scheme. The impact of RH bogus on TCs was known to be large from previous investigations and due to the uncertainties as to its impact, the option to insert RH bogus near TCs was withdrawn from April 1994.

In 1993 it was decided to undertake a joint project with Dr. Johnny Chan of City Polytechnic, Hong Kong to incorporate some of the results of his studies of TC structure (Chan and Williams, 1987) into a new bogus technique to be tested and, if results were favourable, implemented in the UKMO global model.

Formulation of the New Technique

The new technique produces bogus wind observations at the surface, 850hPa, 700hPa and 500hPa on rings of radius 2°, 4° and optionally 6° and 8° depending on the strength of the storm. There are 4, 6, 8 and 10 bogus points on each ring respectively (see Figure 2). A profile of wind speed at the surface is constructed by using information from TC advisories (e.g. radius of 35, 50, 100 knot winds) and combining these with any real observations of surface or low level winds in the area. In this respect it is similar to bogussing methods

used by the NOGAPS model (Fiorino et al., 1993). More sophisticated profiling methods were considered, but following experimentation it was decided that the most practical method was to use a simple exponential curve fitting routine to produce a best-fit curve through these observations. Tangential bogus winds could then be derived from this curve at the appropriate distance from the centre of the TC. An inflow angle of 12° at the surface is imposed on all rings of bogus winds. Pathack (1994) suggested that the inflow angle of 20° used in the current bogus scheme may result in an exaggerated convergence at low levels. Bogus wind speed reduction in the vertical is based on the profile derived by Andersson and Hollingsworth (1988). The only information available in real time which gives an indication of the steering flow is the current or past 6-hours movement of the storm included on TC advisories. This value is imposed on each of the bogus wind values already derived by a simple vector addition and will result in an asymmetric wind structure in the bogus observations being created.

3. TRIALS OF THE NEW TECHNIQUE

3.1 Preliminary Trial

Prior to coding the new scheme into the model and carrying out a lengthy test, five individual cases were selected to evaluate the potential and best configuration of the scheme. In each case the new bogus observations were manually derived and used in two successive 3-day forecast runs (12 hours apart). Seven or eight different configurations of the new scheme were tested in each case. In addition, a control run was made (using the same bogus observations as were used operationally) and a "no bogus" run was also made.

Table 1 shows the mean direct positional errors (DPEs) for three of the experiments run in each case - the trial, control and "no bogus" runs. The trial results shown are those for the configuration of the scheme which was eventually decided to be the best overall. It must be noted that Cases 1 to 4 were chosen because operational forecast errors were large and there was much room for improvement. Case 5 (a "good" operational case) was run to ensure that the new scheme did not perform significantly worse than the operational scheme when there was little room for improvement.

These results indicate that the new bogussing technique reduced analysis errors by an average of 63% and forecast errors by between 42% and 52% when compared to the current bogussing technique. In Cases 1 to 4 every analysis and forecast was better in the trial run. In Case 5 (the "good" case), the trial forecasts overcompensated for the poleward bias in the control forecasts at T+24 and T+48 and hence the errors were larger. However, trial run errors were smaller at T+0 and at T+72.

In every case the trial forecasts reduced the polewards bias present in the control and "no bogus" forecasts. Figure 3 shows the most striking example of this. Plotted are the observed track of TC Edwina (Case 4), the "no bogus" forecast track and the best forecast track using the new bogussing scheme. The T+72 forecast error of 810km in the "no bogus" forecast was reduced to 53km by the new bogus scheme.

Clearly, these results justified proceeding further with the new scheme, but on their own would not justify operational implementation since only five cases were run and four of these were hand-picked because operational errors were large and left much room for improvement. Testing over a longer period with a random sample of cases would be necessary.

3.2 Parallel Suite Trial

Following the preliminary trial, the new bogussing technique was coded into the observation processing section of the model (but not installed operationally) and an interface provided whereby the forecaster could present the relevant information from TC advisories to the model. This interface is necessary since currently the most reliable sources of information required for the new bogussing scheme are not received in machine readable form.

The new bogussing technique underwent a full trial on the Parallel Suite (PS) between 25th August and 12th September 1994 during an active part of the northern hemisphere TC season. During the trial the IF continued to use current TC bogussing techniques as he felt necessary and the bogus observations were presented to the operational (OP) run. However, these operational TC bogus observations were removed from the PS and in place of them the IF supplied the relevant information from TC advisories for each storm every 6 hours in order to generate the new form of bogus observations in the PS run only. The PS ran a continuous observation processing and assimilation cycle and produced a 5-day forecast from the 12UTC run of the model each day. The observations presented to the OP and PS runs were identical except for bogus observations near to TCs.

Verification of the results from the PS trial are detailed in Section 4.

4. VERIFICATION OF RESULTS

4.1 Objective Verification of Tropical Cyclone Track Forecasts

An objective TC verification system has been developed at the UKMO and is used to routinely verify the forecast positions of all TCs (Heming, 1994).

For every forecast of a TC it is able to produce DPE figures as well as errors in the north-south, east-west, cross-track and along-track directions. In some basins a comparison with CLIPER models is also made and a skill score for the NWP model forecast obtained. The verification scheme uses the 850hPa relative vorticity field to locate the centre of the TC in the model and uses advisory positions primarily from Guam, Miami and Honolulu as the verifying observations of the storm location.

There were 12 active tropical storms during the trial period; 7 in the western North Pacific, 4 in the eastern and central North Pacific and 1 in the North Atlantic. Of these 5 reached a maximum sustained wind greater than 60 knots and a further 2 reached a maximum sustained wind greater than 120 knots. For the duration of the trial each main run analysis was verified (00UTC and 12UTC) and each 12UTC forecast was verified for both the OP and PS runs. The PS only runs one forecast per day from data time (DT) 12UTC.

Table 2 shows the total number of analyses and forecasts verified during the course of the trial. The numbers become smaller at later forecast times since a forecast is only verified if there is a valid observed position at the verifying time and the storm centre in the model is equatorwards of 40° latitude and sufficiently strong to be verified (a predetermined threshold value of relative vorticity is used for this purpose). The figures at T+0 are the same for the OP and PS runs since the verification scheme forces verification of analyses if there is a valid observations against which to verify. However, it is notable that at all forecast times more PS forecasts were verified than OP forecasts. Since the verifying observations were the same in each run this indicates that the PS run correctly maintained a stronger circulation or held storms nearer the equator on more occasions than the OP run.

In all subsequent error statistics quoted, forecasts which were verified by one run, but not the other have been eliminated so as to provide equal and comparable samples for verification.

Table 3 is a summary of the mean forecast positional errors for all 12 storms and is illustrated graphically in Figure 4. Analysis errors were cut by almost two-thirds by the PS run to a mean value of 39km which approximates to one third of a model grid length. Mean forecast errors were reduced by between a quarter and a half by the PS run and skill scores against CLIPER models were also significantly increased.

Table 3 also shows the relative number of PS analyses/forecasts which were better than OP (i.e. DPE was smaller) and vice versa. The vast majority of PS analyses were better than OP analyses and more than twice as many PS forecasts were better than OP forecasts.

Tables 4-15 show the figures for each individual TC active during the trial period. Of the twelve individual storms, the mean errors were smaller at every forecast time in the PS run for nine of them. In two cases the OP errors were only slightly smaller at T+48 and T+72 (for TC Gladys, Table 5) and at T+24 (for TC Luke, Table 13). In the last case (TC Melissa, Table 15), the PS run's analyses and T+24 forecasts were far better than the OP run, but the OP run forecasts at T+48 and beyond were better than the PS run. This case will be discussed in more detail in Section 4.3.

4.2 Objective Verification Against Observations

Results in Section 4.1 have shown that the new TC bogus scheme has had a large beneficial impact on the forecast of TCs themselves. However, the bogussing of TCs will have some effect on model fields on a broader scale than just the immediate vicinity of the storm and this may not always be a positive impact. Heming (1990(b)) details a case of TC bogussing resulting in the spurious over-strengthening of a mid-latitude jet. In order to assess any broader scale impact, objective verification against observations was run for the trial period and selected RMS error statistics are shown in Tables 16-18 for areas 2 (North Atlantic area), 200 (north of 20°N) and 300 (20°S - 20°N). These are expressed in proportional terms - values less than 100 indicate that the PS errors were smaller, values greater than 100 indicate that the OP errors were smaller.

Charts of model fields were produced routinely during the trial and indicated differences between the OP and PS runs not only in the areas near to TCs, but across the globe. As the trial progressed differences were even noted in southern hemisphere high latitude areas. It was considered that these could only be due to differences in levels of noise between the Operational and Parallel Suites since all TCs during the trial were in the northern hemisphere and it was considered unlikely that differences resulting from bogussing could propagate this far. Variations of more than 1% between the OP and PS RMS error statistics were considered to be above the variation in noise levels in the two suites. Of the 468 error categories considered in total in the regions above, the PS run had RMS errors more than 1% smaller than the OP run in 40 of them. The OP run had errors more than 1% smaller than the PS run in just 10 categories. This firstly indicates that the PS run error statistics were better, but also that the majority of differences were near to noise levels as would be expected when the impact of bogussing near to TCs is averaged over a large area. Interestingly, wind errors in the tropics were better in the OP run analyses, but better in the PS run forecasts. The most notable differences were in low-level heights in the tropics between T+24 and T+72 which were reduced by the PS run by up to nearly 5% (see Table 18). Overall, these figures

illustrate that the new bogussing technique does not have a detrimental effect on broader scale model fields.

4.3 Subjective Verification of Individual Cases

As mentioned in Section 4.1 forecasts for TC Melissa, which fell at the end of the trial period, were interesting since the PS run's analyses and T+24 forecasts were far better than the OP run, but the OP run forecasts at T+48 and beyond were better than the PS run (see Table 15). Figures 5(a) and (b) show OP and PS forecast tracks from DT 12UTC 11.09.94 and indicate that neither forecast successfully predicted the sudden change in direction of the storm early in its lifetime and both showed a similar track in terms of direction, but the OP track was displaced to the east of the PS track. Since the OP run erroneously analysed the storm further to the east, its forecasts at T+48 and beyond were fortuitously more accurate.

Figures 6-8 are examples of where forecast tracks from the PS run were better than those from the OP run. Figure 6(a) shows an OP forecast track up to T+48 for TC Kristy. The forecast track was far too slow resulting in large errors. In the PS run, however (Figure 6(b)), the forecast track, despite being slightly poleward of the actual track, was much better in terms of speed of movement and consequently forecast errors were small. Table 8 shows DPE values for TC Kristy and also along-track (AT) errors. The AT statistics show how the PS forecasts reduced the slow bias which was present in the OP run.

Figures 7(a) and (b) show the OP and PS analyses and T+24 forecasts for TC Lane. There was a polewards bias in the OP analyses which grew larger by T+24 whereas the PS analyses and T+24 forecasts were almost perfect. Table 9 shows the massive reduction in analysis and T+24 errors which the PS run produced.

Figures 8(a) and (b) show the OP and PS forecasts for TC John from DT 12UTC 29.08.94. The OP forecast steered the storm north much too soon. The PS forecast track is not clear from the chart since it correctly stalled the TCs movement for several days.

This last case showed the most dramatic differences of the whole trial period between the OP and PS runs. Figures 9(a) and (b) show the OP and PS analyses for TCs John and Ivy which were in close proximity at the time. The PS gave a slightly better initial position for both storms. The subsequent forecast development for the two runs was completely different. The OP forecast steered John northwards and held Ivy near to 30°N (see T+120 forecast, Figure 10(a)) whereas the PS forecast steered Ivy northwards and held John almost stationary (Figure 10(b)). The verifying analysis (Figure 11) shows

that the PS forecast was far superior. OP 5-day forecast errors of 1298km and 901km for John and Ivy respectively were reduced to 117km and 219km by the PS run. The PS run was superior in its forecast development of these two storms for the following three days' forecasts.

The storm which was forecast best by the OP run during the trial was TC Harry (Table 6) with T+0, T+24 and T+48 errors all below 100km. However, it must be noted that even in this case of a good forecast the PS run produced lower analysis and forecast errors than the OP run.

In Section 4.1 it was suggested that the larger number of PS forecasts verified compared to OP forecasts (see Table 2) was due to the PS not dissipating TCs so quickly in the forecast as a result of a better initialisation. An example of this is the forecast of TC Kinna from DT 12UTC 06.09.94. Figures 12(a) and (b) show the OP and PS analyses of the storm which was located near 24°N 140°E. The PS analysis shows a distinct circulation in the surface wind flow, whereas the OP analysis simply has a troughing in a broader scale cyclonic development to the south-west. The forecast development (Figures 13-15) shows that the OP run never featured more than a weak trough which was too weak to be verified by the TC verification scheme. The PS, however, maintains a distinct circulation and the verifying analysis for the T+72 forecast (Figure 16) shows that although not positionally perfect the PS forecast correctly developed the system which by that time had a maximum sustained wind of 75 knots according to TC advisory bulletins.

5.CONCLUSIONS

The impact of a new TC bogussing technique has been assessed by carrying out two separate trials. The first was performed on a small number of hand-picked cases and the second by carrying out a 19 day continuous trial during August and September 1994 using the PS. In both trials all operational bogus observations in the vicinity of TCs were omitted and the new type of TC bogus observations included in a parallel run of the UKMO global model. A full assimilation cycle and one 5-day forecast per day were run during the trial using the PS.

There were twelve active TCs during the PS trial period each of which had its forecast tracks verified using the Central Forecasting TC verification scheme. These results showed that the new bogussing scheme produced a very large reduction in mean analysis and forecast errors. Positional errors were smaller in the vast majority of individual analyses and forecasts verified for the PS run. PS forecasts also tended to correctly maintain a stronger circulation of TCs later into the forecast period. The new bogussing scheme was also able to

produce an improvement in the forecast of a storm which was already forecast well by the OP run.

Individual cases have been presented to support each of the above results and in one case in particular, the forecast evolution of a dual TC system was improved for several successive runs by the use of the new bogussing technique.

Verification against observations was carried out for the tropics and northern hemisphere to ensure that the new bogussing scheme was not producing any unwanted effects on a broader scale. Overall, these statistics tended to indicate a small reduction in errors as a result of using the new scheme although variation in noise levels between the two runs may have disguised the detailed signal in these statistics. However, the results were able to confirm that the new scheme appeared not to be introducing any unwanted systematic bias into model forecast fields on a broader scale.

On the basis of these results the new TC bogus scheme was made operational on 25th October 1994. Instructions issued to IFs on the use of the new scheme are detailed in Appendices 1-4.

6.ACKNOWLEDGEMENTS

The inspiration and original ideas behind this new bogussing technique came from Dr. Johnny Chan of City Polytechnic, Hong Kong. My thanks to him and also Alan Radford for helpful input and guidance during the formulation and testing of the new technique.

Thanks must also go to the Intervention Forecasters and assistants in the CFO who diligently carried out the input of TC advisory information during the Parallel Suite trial and contributed to its success. The Parallel Suite experiment was conducted under the direction of Sharon Bean and Chris Hynes of CF4.

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APPENDIX 1

INSTRUCTIONS FOR NEW TROPICAL CYCLONE BOGUSSING SCHEME (PF7)

1. The PF7 option should be used for **every numbered** TC advisory received from Guam (PGTW), Miami (KMIA) or Honolulu (PHNL) - i.e. bogus each storm every six hours. Guam usually issue advisories for all southern hemisphere storms, but if they don't, there is usually enough information on advisories from Réunion, Fiji etc., to enable use of the PF7 option. Indicate bogussing has been completed in the column headed "PF7" on the tick sheet. See Appendices 2-4 for details of the information required by the PF7 option.

2. Bogus at the hour of the advisory. e.g. Miami and Honolulu advisories are normally valid at 03Z, 09Z, etc. Specify this time rather than trying to interpolate information to the nearest main hour.

3. If any of the radius of 35 (or 34), 50, 65 (or 64) or 100 knot winds are not quoted on the advisory (or not applicable) leave as "999" on the panel. Position, maximum sustained wind and current or recent movement must be entered.

4. If different radii are quoted for different quadrants of the storm use an approximate mean value (see Appendix 3 for example).

5. Concern has been expressed that advisory values of maximum sustained wind are sometimes exaggerated. This value is, in fact, only used as a guide to the scheme as to the approximate strength of the storm and hence will not artificially increase the bogus wind values which are generated.

6. PF7 bogus appear in DISPINT as records headed "DBC" and are listed in the QrhhAOIN output. On Plots the position of the storm centre and its maximum sustained wind will appear as a single point with identifier "CFOTropC" if in status mode. If in quality control mode the individual bogus observations generated by the scheme will also be plotted *after* each main run with identifiers "CFOTCBOG". These will also be listed in the QrhhAOLP output.

Appendix 2

New "PF7" option available to Intervention

NEW TROPICAL CYCLONE BOGUS SCHEME

DATE/TIME: 250000GMT.

TC CENTRE POSITION
LATITUDE N/S ***** * LONGITUDE E/W ***** *
MAXIMUM SUSTAINED WIND
SPEED IN KNOTS (RANGE 20-195) ***

RADIUS OF 35/50/65/100 KNOT WINDS (IN NAUTICAL MILES FROM TC CENTRE)
35 KNOTS 999 50 KNOTS 999 65 KNOTS 999 100 KNOTS 999

CURRENT OR RECENT MOVEMENT OF TC - DEGREES (DDD) KNOTS (FFF)
DDDDFF

DATE/TIME AND ALL DEFAULT VALUES CAN BE OVERTYPED

PRESS <ENTER> AFTER EACH ENTRY BEFORE ENDING OPTION
WHEN CURRENT ENTRY COMPLETE:----- PRESS <ENTER>
END OPTION:----- PRESS <PF24>

THIS OPTION IS NOW OPERATIONAL
USE IN PREFERENCE TO OTHER OPTIONS FOR OPERATIONAL TC BOGUSSING

Match each of the numbered inputs with those on the
advisory examples (Appendices 3 and 4)

Appendix 3 Example of advisory from Guam

ZCZC 744

WTPN31 PGTH 190900

1. SUPER TYPHOON WALT (10W) WARNING NR 20
03 ACTIVE TROPICAL CYCLONES IN NORTHWESTPAC
MAX SUSTAINED WINDS BASED ON ONE-MINUTE AVERAGE

WARNING POSITION:

- 1 - [190600Z6 --- 21.5N8 132.7E3] 2,3
MOVEMENT PAST SIX HOURS - 025 DEGREES AT 09 KTS] 9
POSITION ACCURATE TO WITHIN 030 NM
POSITION BASED ON EYE FIXED BY A COMBINATION OF
SATELLITE AND EXTRAPOLATION

PRESENT WIND DISTRIBUTION:

- MAX SUSTAINED WINDS - 130 KT 4 GUSTS 160 KT
RADIUS OF 100 KT WINDS - 030 NM
8

PAGE 03 RUHQ8GG4001 UNCLAS

- RADIUS OF 050 KT WINDS - 080 NM SOUTHEAST SEMICIRCLE
050 NM ELSEWHERE } 6 Use mean value of 60NM
RADIUS OF 035 KT WINDS - 170 NM SOUTHEAST SEMICIRCLE
140 NM ELSEWHERE } 5 Use mean value of 150NM

REPEAT POSIT: 21.5N8 132.7E3

FORECASTS:

12 HRS, VALID AT:

191800Z9 --- 22.9N3 133.4E1

MAX SUSTAINED WINDS - 130 KT, GUSTS 160 KT

RADIUS OF 100 KT WINDS - 030 NM

RADIUS OF 050 KT WINDS - 080 NM SOUTHEAST SEMICIRCLE
050 NM ELSEWHERE

RADIUS OF 035 KT WINDS - 170 NM SOUTHEAST SEMICIRCLE
140 NM ELSEWHERE

VECTOR TO 24 HR POSIT: 020 DEG/ 10 KTS

24 HRS, VALID AT:

200600Z8 --- 24.7N3 134.3E1

MAX SUSTAINED WINDS - 130 KT, GUSTS 160 KT

PAGE 04 RUHQ8GG4001 UNCLAS

RADIUS OF 100 KT WINDS - 030 NM

RADIUS OF 050 KT WINDS - 080 NM EAST SEMICIRCLE
050 NM ELSEWHERE

RADIUS OF 035 KT WINDS - 170 NM EAST SEMICIRCLE
140 NM ELSEWHERE

VECTOR TO 36 HR POSIT: 015 DEG/ 09 KTS

NNNN

Appendix 4

Example of advisory from Honolulu

ZCZC 631

JTPA25 PHNL 181500

HURRICANE EMILIA MARINE ADVISORY NUMBER 11

NATIONAL WEATHER SERVICE HONOLULU HI

1500Z MON JUL 18 1994

HURRICANE CENTER LOCATED NEAR 10.9N 145.1W AT 18/1500ZPOSITION ACCURATE WITHIN 20 NM 2 3 1PRESENT MOVEMENT TOWARD THE WEST OR 275 DEGREES AT 15 KTESTIMATED MINIMUM CENTRAL ⁴ PRESSURE 950 MB ⁹MAX SUSTAINED WINDS 125 KT WITH GUSTS TO 150 KT

64 KT..... 30NE 30SE 30SW 30NW]-7

50 KT..... 50NE 50SE 50SW 50NW]-6

34 KT.....125NE 125SE 125SW 125NW]-5

12 FT SEAS..125NE 125SE 125SW 125NW

ALL QUADRANT RADII IN NAUTICAL MILES

REPEAT...CENTER LOCATED NEAR 10.9N 145.1W AT 18/1500Z

AT 18/1200Z CENTER WAS LOCATED NEAR 10.8N 144.3W

FORECAST VALID 19/0000Z 11.2N 147.4W

MAX WIND 130 KT...GUSTS 160 KT

50 KT... 50NE 50SE 50SW 50NW

34 KT...130NE 130SE 130SW 130NW

FORECAST VALID 19/1200Z 11.7N 150.2W

MAX WIND 140 KT...GUSTS 170 KT

50 KT... 60NE 60SE 60SW 60NW

34 KT...140NE 140SE 140SW 140NW

FORECAST VALID 20/0000Z 12.6N 152.5W

MAX WIND 130 KT...GUSTS 160 KT

50 KT... 50NE 50SE 50SW 50NW

34 KT...130NE 150SE 130SW 150NW

REQUEST FOR 3 HOURLY SHIP REPORTS WITHIN 300 MILES OF 11N 145W

EXTENDED OUTLOOK...USE FOR GUIDANCE ONLY...ERRORS MAY BE LARGE

OUTLOOK VALID 20/1200Z 13.6N 154.4W

MAX WIND 115 KT...GUSTS 140 KT

50 KT... 50NE 50SE 50SW 50NW

OUTLOOK VALID 21/1200Z 15.9N 157.9W

MAX WIND 90 KT...GUSTS 110 KT

50 KT... 40NE 40SE 40SW 40NW

NEXT ADVISORY AT 18/2100Z

		T+0	T+24	T+48	T+72
Case 1 YVETTE	Trial	15	127	365	428
	Control	41	333	683	1037
	No Bogus	26	256	639	871
	Improvement (%)	63	62	47	59
Case 2 ELSIE	Trial	39	246	312	365
	Control	94	422	664	604
	No Bogus	140	474	681	637
	Improvement (%)	59	42	53	40
Case 3 KORYN	Trial	20	230	447	***
	Control	107	395	621	***
	No Bogus	160	386	618	***
	Improvement (%)	81	42	28	***
Case 4 EDWINA	Trial	73	140	270	362
	Control	117	299	474	710
	No Bogus	309	570	717	789
	Improvement (%)	38	53	43	49
Case 5 EUGENE	Trial	25	150	179	100
	Control	94	81	122	286
	No Bogus	181	54	38	74
	Improvement (%)	73	-46	-32	65
All Storms	Trial	34	179	300	314
	Control	91	306	513	659
	No Bogus	163	348	539	593
	Improvement (%)	63	42	42	52

TABLE 1
Mean Direct Positional Errors for Preliminary Trial

All errors in kilometres

Improvement (%) : Percentage improvement of trial run relative to control run
: Positive value indicates trial errors smaller than control

Storm names, basins and data times of forecast runs :

YVETTE (North-West Pacific) : 12UTC 13.10.92 and 00UTC 14.10.92
ELSIE (North-West Pacific) : 00UTC and 12UTC 31.10.92
KORYN (North-West Pacific) : 12UTC 24.06.93 and 00UTC 25.06.93
EDWINA (South-West Indian) : 12UTC 23.01.93 and 00UTC 24.01.93
EUGENE (North-East Pacific) : 00UTC and 12UTC 18.07.93

	T+0	T+24	T+48	T+72	T+96	T+120
OP	119	46	33	19	13	9
PS	119	50	34	24	19	11

TABLE 2

Total Number of Analyses and Forecasts Verified During the Trial

OP : Operational run
PS : Parallel Suite run

All Storms during Trial Period						
	T+0	T+24	T+48	T+72	T+96	T+120
No. Verified	119	45	29	16	13	8
No. PS better	101	31	20	11	9	6
No. OP better	14	13	9	5	4	2
OP DPE (km)	110	201	326	528	700	818
PS DPE (km)	39	123	240	394	431	440
% Improvement	65	39	26	25	38	46
OP Skill (%)	***	4	9	7	***	***
PS Skill (%)	***	40	32	37	***	***

TABLE 3

Track Verification Statistics for all TCs during the Trial Period

No. Verified : Number of analyses/forecasts verified
No. OP better : Number of analyses/forecasts where OP errors smaller
No. PS better : Number of analyses/forecasts where PS errors smaller
OP DPE : Mean Operational Direct Positional Error
PS DPE : Mean Parallel Suite Direct Positional Error
% Improvement : Mean Percentage improvement of PS relative to OP -
: Positive value indicates PS error smaller than OP error.
OP Skill : Mean Operational skill score relative to CLIPER
PS Skill : Mean Parallel Suite skill score relative to CLIPER

	T+0	T+24	T+48	T+72	T+96	T+120
500hPa Height	100.4	99.7	99.8	98.7	99.7	99.4
250hPa Height	100.0	100.0	99.2	98.7	99.5	98.8
500hPa Temperature	100.0	100.0	100.0	99.4	100.5	100.3
250hPa Temperature	99.5	99.7	100.5	100.0	100.2	99.3
500hPa Wind	99.8	100.1	100.1	100.0	100.0	100.6
250hPa Wind	99.7	99.8	99.7	99.8	99.6	99.8
850hPa Relative Humidity	100.0	100.3	99.9	100.0	99.6	99.2
Mean Sea-Level Pressure	100.4	99.8	99.4	99.1	99.5	100.6

TABLE 16
Verification Against Observations for Area 2 (N.Atlantic Area)

Figures expressed as a ratio (PS RMS error/OP RMS error x 100%)
Values less than 100 indicate PS run errors were smaller

	T+0	T+24	T+48	T+72	T+96	T+120
500hPa Height	99.4	99.1	99.7	99.6	100.2	98.9
250hPa Height	99.7	98.7	99.3	99.5	100.4	99.1
850hPa Temperature	100.4	100.1	100.2	99.9	100.1	99.3
500hPa Temperature	99.9	100.0	100.3	99.3	100.2	99.7
850hPa Wind	100.6	100.3	100.6	100.5	99.5	99.9
500hPa Wind	101.1	100.4	100.6	99.5	99.3	99.6
250hPa Wind	99.9	99.8	100.0	99.6	99.4	98.9
850hPa Relative Humidity	99.9	100.1	100.1	100.0	100.2	99.2
Mean Sea-Level Pressure	99.9	100.1	100.1	99.6	99.3	100.1

TABLE 17

Verification Against Observations for Area 200 (North of 20°N)

Figures expressed as a ratio (PS RMS error/OP RMS error x 100%)

Values less than 100 indicate PS run errors were smaller

	T+0	T+24	T+48	T+72	T+96	T+120
850hPa Height	100.7	97.8	95.3	95.1	100.0	98.4
500hPa Height	100.5	99.2	98.6	98.5	100.1	99.2
850hPa Temperature	99.7	100.2	99.9	99.6	99.8	99.7
500hPa Temperature	100.1	100.5	99.7	99.6	100.4	100.0
850hPa Wind	102.2	99.7	99.2	99.3	99.9	100.4
500hPa Wind	102.2	99.2	97.5	98.2	98.9	99.8
850hPa Relative Humidity	100.0	100.1	100.0	99.7	99.9	98.7
Mean Sea-Level Pressure	99.9	99.2	98.8	98.3	99.6	99.2

TABLE 18

Verification Against Observations for Area 300 (20°S - 20°N)

Figures expressed as a ratio (PS RMS error/OP RMS error x 100%)

Values less than 100 indicate PS run errors were smaller

SUMMARY OF FIGURES

- Figure 1 Observed and Forecast Tracks for TC Koryn, June 1993
- Figure 2 Approximate Horizontal Distribution of Bogus Points
- Figure 3 Observed and Forecast Tracks for TC Edwina from DT 00UTC 24.01.93
- Figure 4 Mean TC Forecast Errors for OP and PS runs
- Figure 5(a) OP Forecast Track for TC Melissa, DT 12UTC 11.09.94
Figure 5(b) PS Forecast Track for TC Melissa, DT 12UTC 11.09.94
- Figure 6(a) OP Forecast Track for TC Kristy, DT 12UTC 31.08.94
Figure 6(b) PS Forecast Track for TC Kristy, DT 12UTC 31.08.94
- Figure 7(a) OP Forecast Tracks for TC Lane
Figure 7(b) PS Forecast Tracks for TC Lane
- Figure 8(a) OP Forecast Track for TC John, DT 12UTC 29.08.94
Figure 8(b) PS Forecast Track for TC John, DT 12UTC 29.08.94
- Figure 9(a) OP analysis for TCs John and Ivy, DT 12UTC 29.08.94
Figure 9(b) PS analysis for TCs John and Ivy, DT 12UTC 29.08.94
- Figure 10(a) OP T+120 Forecast for TCs John and Ivy, DT 12UTC 29.08.94
Figure 10(b) PS T+120 Forecast for TCs John and Ivy, DT 12UTC 29.08.94
- Figure 11 Verifying Analysis for TCs John and Ivy, DT 12UTC 03.09.94
- Figure 12(a) OP Analysis for TC Kinna, DT 12UTC 06.09.94
Figure 12(b) PS Analysis for TC Kinna, DT 12UTC 06.09.94
- Figure 13(a) OP T+24 Forecast for TC Kinna, DT 12UTC 06.09.94
Figure 13(b) PS T+24 Forecast for TC Kinna, DT 12UTC 06.09.94
- Figure 14(a) OP T+48 Forecast for TC Kinna, DT 12UTC 06.09.94
Figure 14(b) PS T+48 Forecast for TC Kinna, DT 12UTC 06.09.94
- Figure 15(a) OP T+72 Forecast for TC Kinna, DT 12UTC 06.09.94
Figure 15(b) PS T+72 Forecast for TC Kinna, DT 12UTC 06.09.94
- Figure 16 Verifying Analysis for TC Kinna, DT 12UTC 09.09.94

FROM 17. 6.1993 TO 28. 6.1993 IN THE NWP BASIN
OBSERVED TRACK WITH FORECASTS TO T+120 HOURS
CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

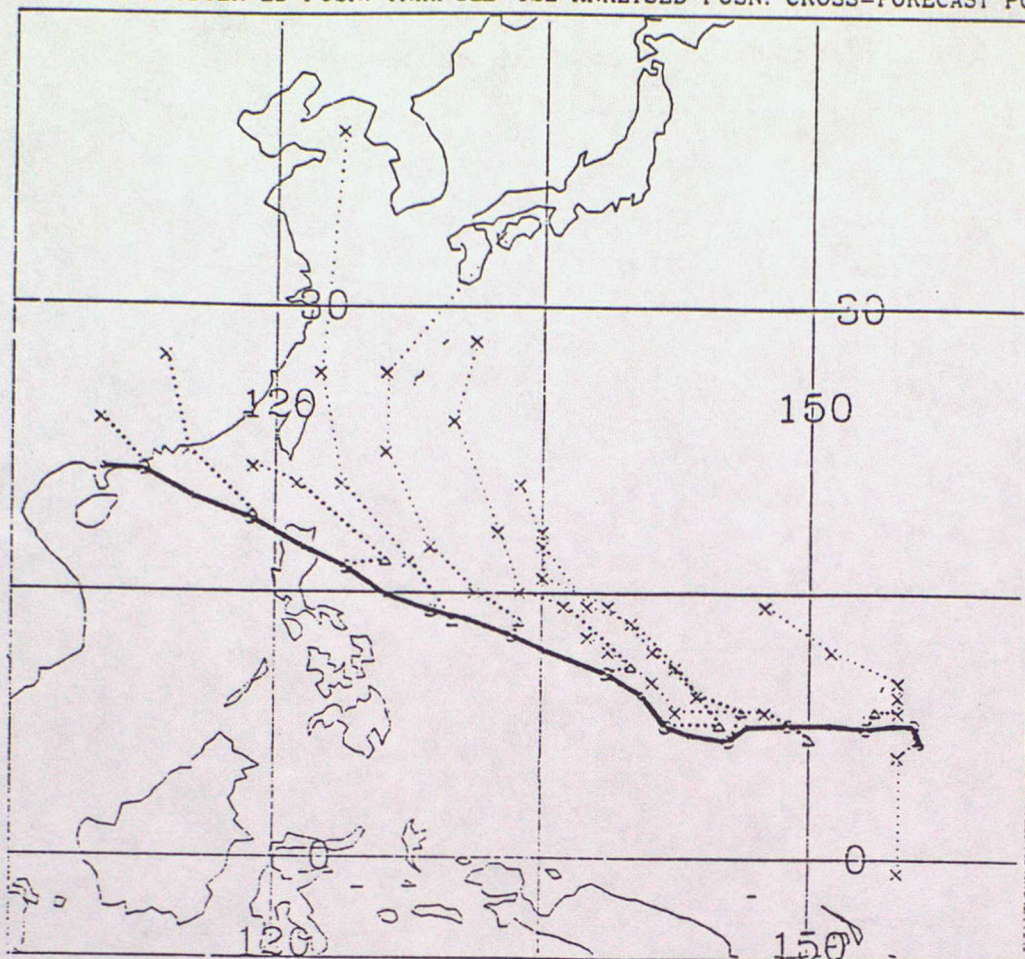


Figure 1
Observed and Forecast Tracks for TC Koryn, June 1993

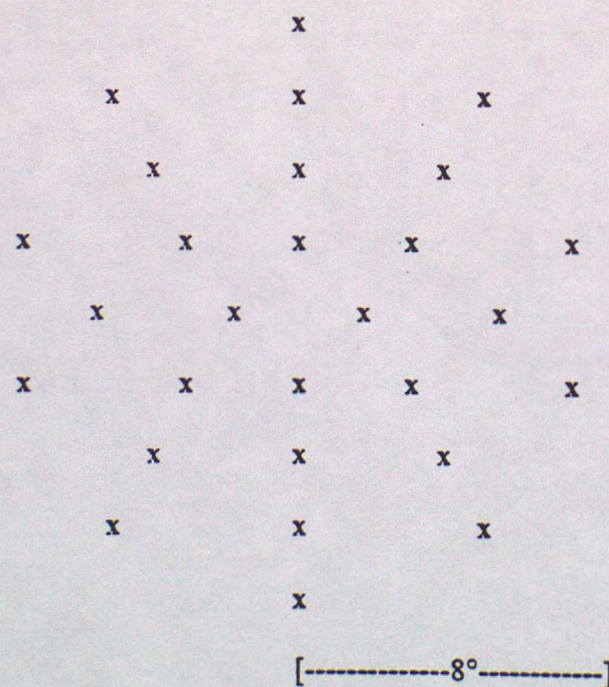


Figure 2
Approximate Horizontal Distribution of Bogus Points

Solid line : Actual track with 24-hourly positions plotted
 Dashed line with crosses : Forecast track with new bogus scheme
 Dashed line with circles : Forecast track with no bogus

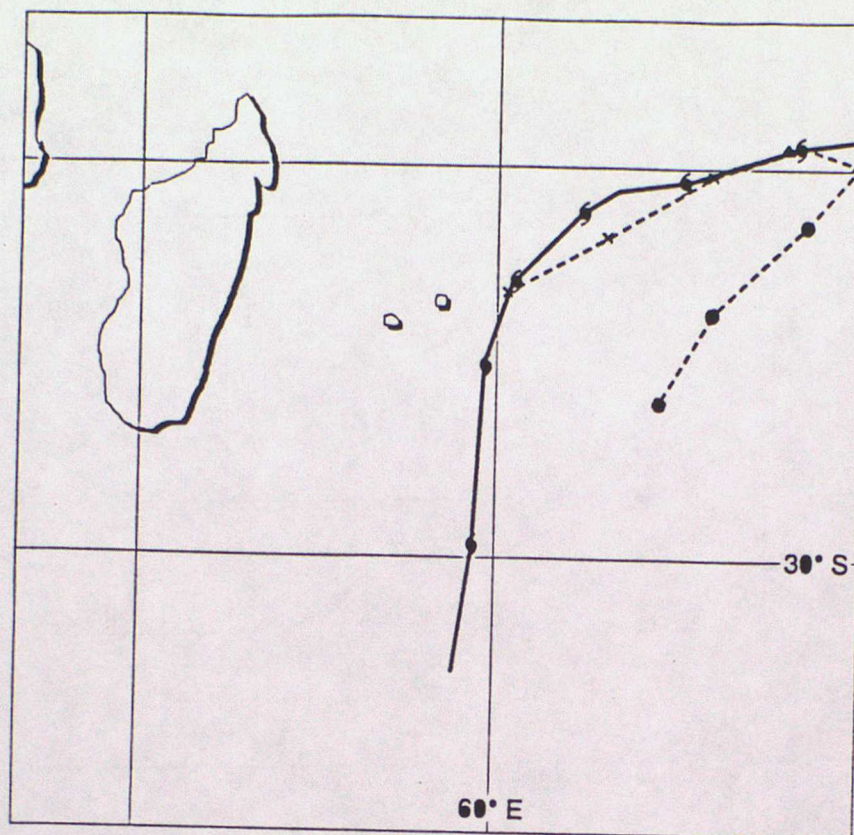


Figure 3
 Observed and Forecast Tracks for TC Edwina from DT 00UTC 24.01.93

Tropical Cyclone Forecast Errors During Trial of New Bogussing Scheme

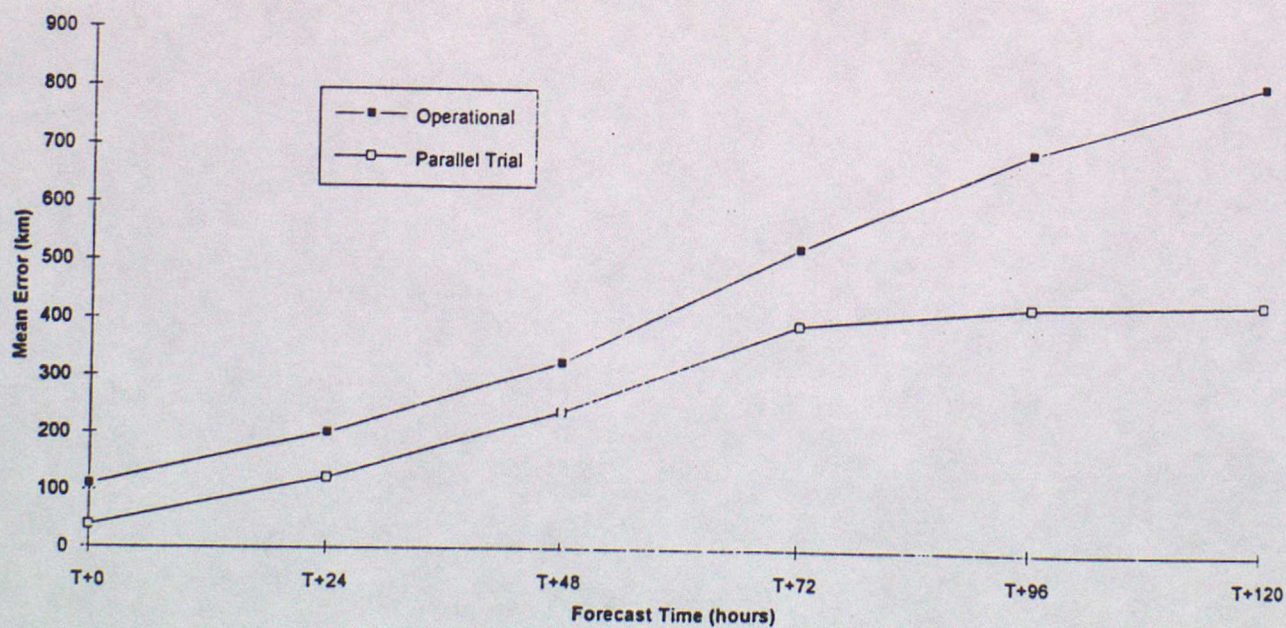


Figure 4
 Mean TC Forecast Errors for OP and PS runs

FROM 11. 9.1994 TO 18. 9.1994 IN THE NWP BASIN
OBSERVED TRACK WITH FORECASTS TO T+120 HOURS
CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

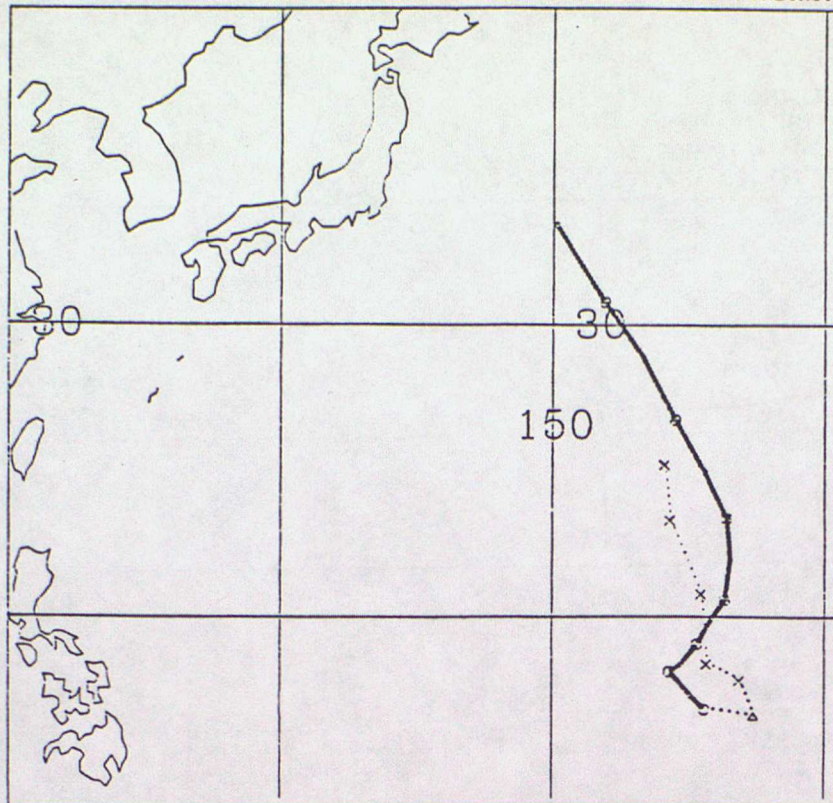


Figure 5(a)
OP Forecast Track for TC Melissa, DT 12UTC 11.09.94

TROPICAL CYCLONE MELISSA.
FROM 11. 9.1994 TO 18. 9.1994 IN THE NWP BASIN
OBSERVED TRACK WITH FORECASTS TO T+120 HOURS
CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

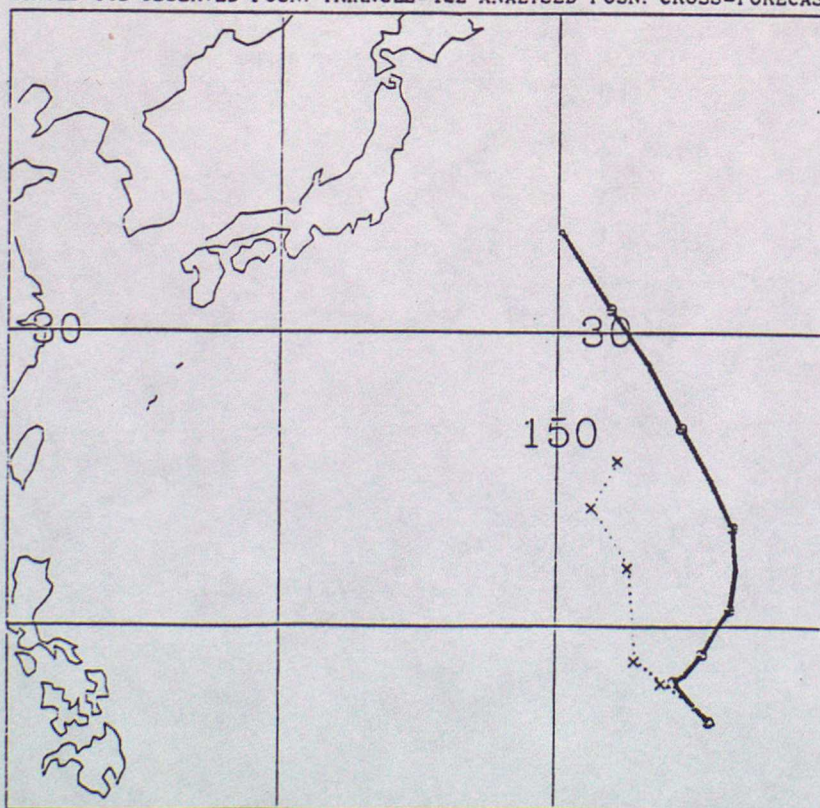


Figure 5(b)
PS Forecast Track for TC Melissa, DT 12UTC 11.09.94

TROPICAL CYCLONE KRISTY. OPERATIONAL
 FROM 30. 8.1994 TO 3. 9.1994 IN THE NEP BASIN
 OBSERVED TRACK WITH FORECASTS TO T+ 48 HOURS
 CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

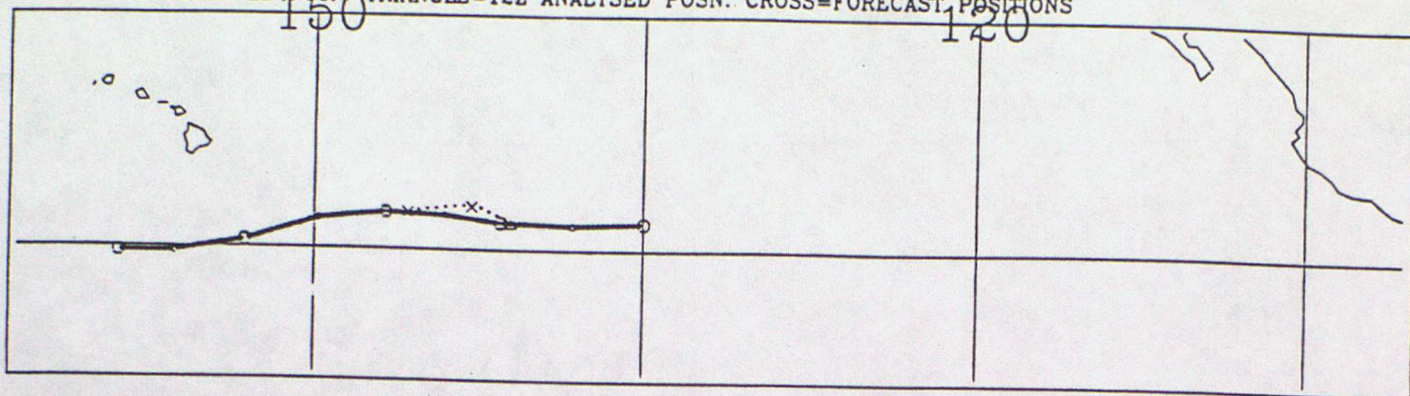


Figure 6(a)
 OP Forecast Track for TC Kristy, DT 12UTC 31.08.94

TROPICAL CYCLONE KRISTY. TRIAL
 FROM 30. 8.1994 TO 3. 9.1994 IN THE NEP BASIN
 OBSERVED TRACK WITH FORECASTS TO T+ 48 HOURS
 CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

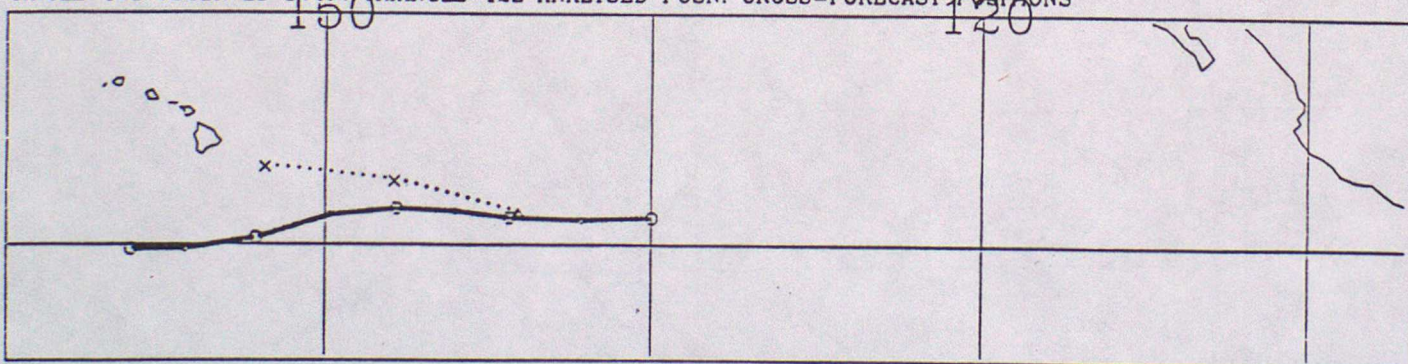


Figure 6(b)
 PS Forecast Track for TC Kristy, DT 12UTC 31.08.94

TROPICAL CYCLONE LANE. OPERATIONAL
 FROM 4. 9.1994 TO 9. 9.1994 IN THE NEP BASIN
 OBSERVED TRACK WITH FORECASTS TO T+ 24 HOURS
 CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

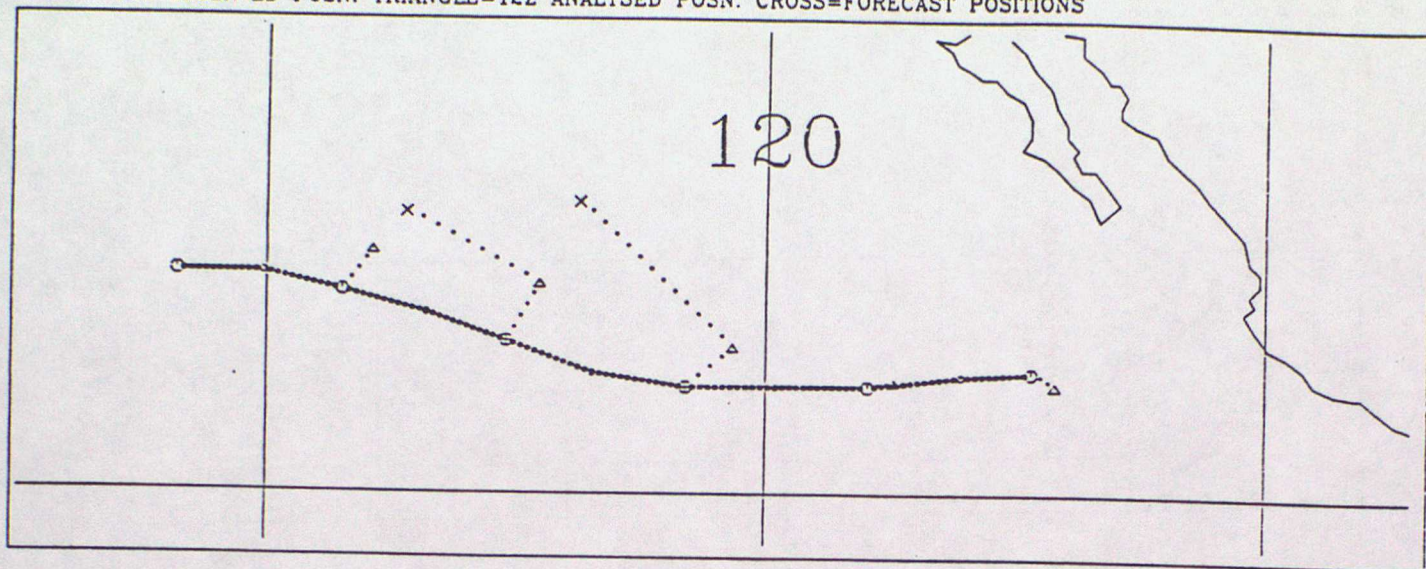


Figure 7(a)
 OP Forecast Tracks for TC Lane

TROPICAL CYCLONE LANE. TRIAL
 FROM 4. 9.1994 TO 9. 9.1994 IN THE NEP BASIN
 OBSERVED TRACK WITH FORECASTS TO T+ 24 HOURS
 CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

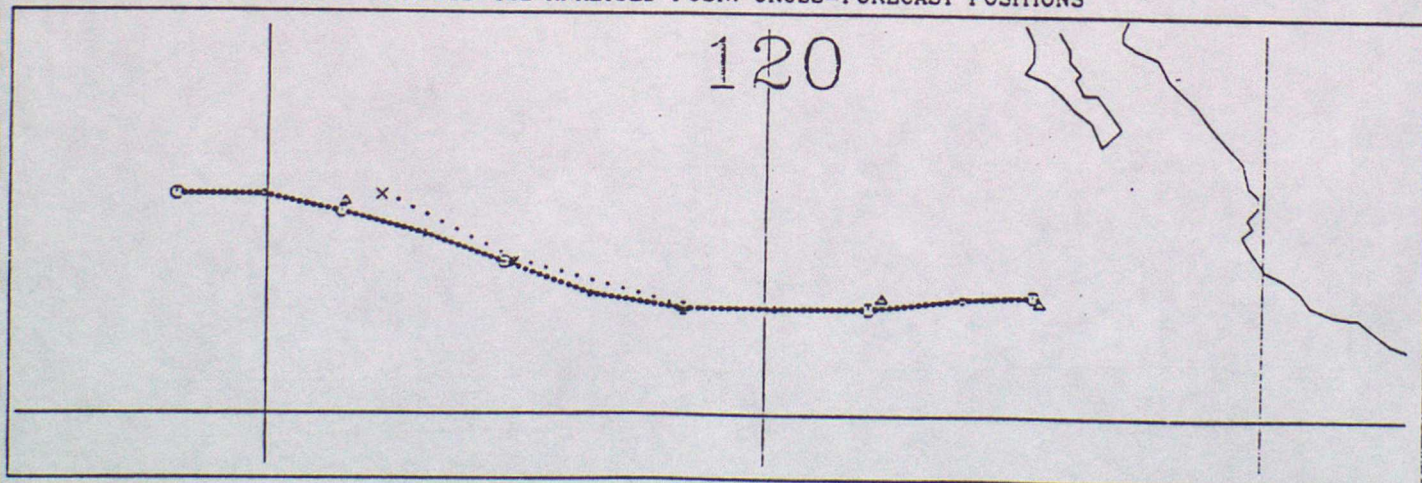


Figure 7(b)
 PS Forecast Tracks for TC Lane

TROPICAL CYCLONE JOHN. OPERATIONAL
 FROM 25. 8.1994 TO 10. 9.1994 IN THE NEP BASIN
 OBSERVED TRACK WITH FORECASTS TO T-120 HOURS
 CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

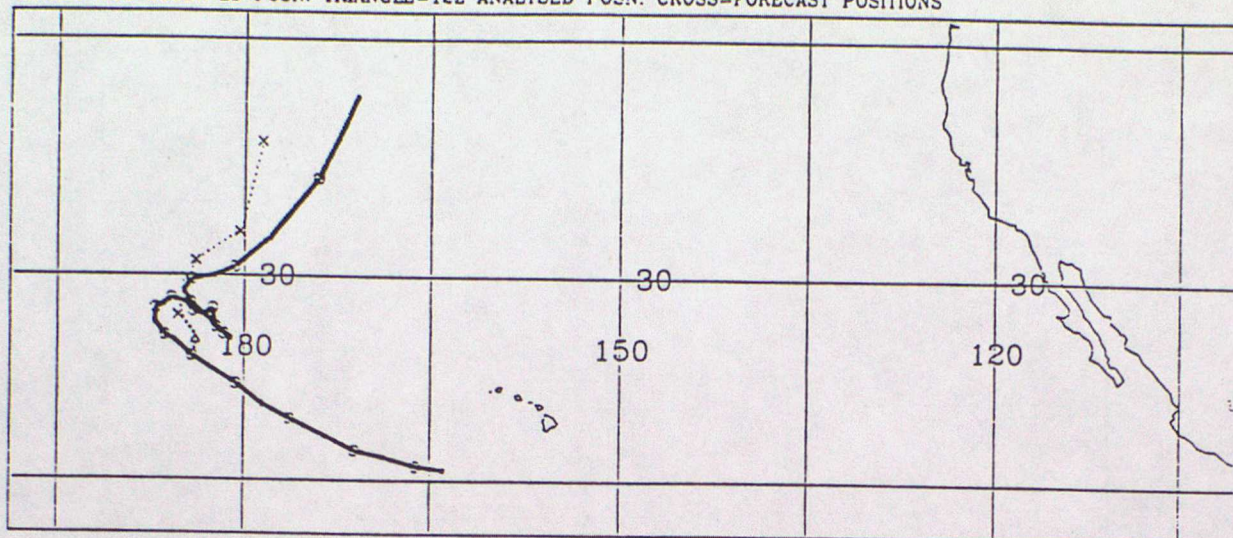


Figure 8(a)
 OP Forecast Track for TC John, DT 12UTC 29.08.94

TROPICAL CYCLONE JOHN. TRIAL
 FROM 25. 8.1994 TO 10. 9.1994 IN THE NEP BASIN
 OBSERVED TRACK WITH FORECASTS TO T-120 HOURS
 CIRCLE=12Z OBSERVED POSN. TRIANGLE=12Z ANALYSED POSN. CROSS=FORECAST POSITIONS

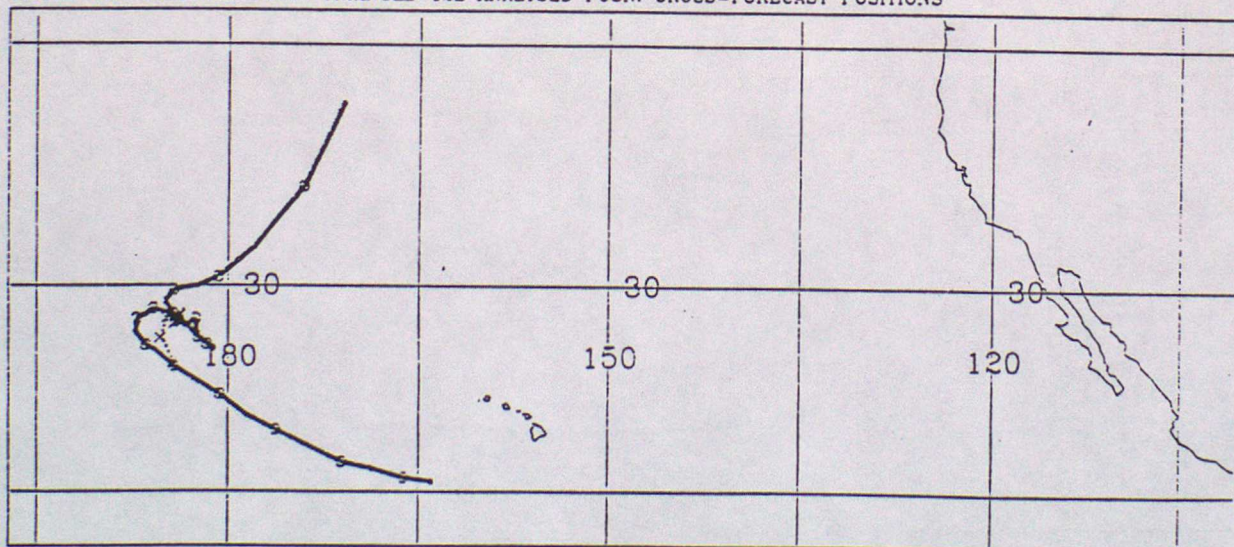


Figure 8(b)
 PS Forecast Track for TC John, DT 12UTC 29.08.94

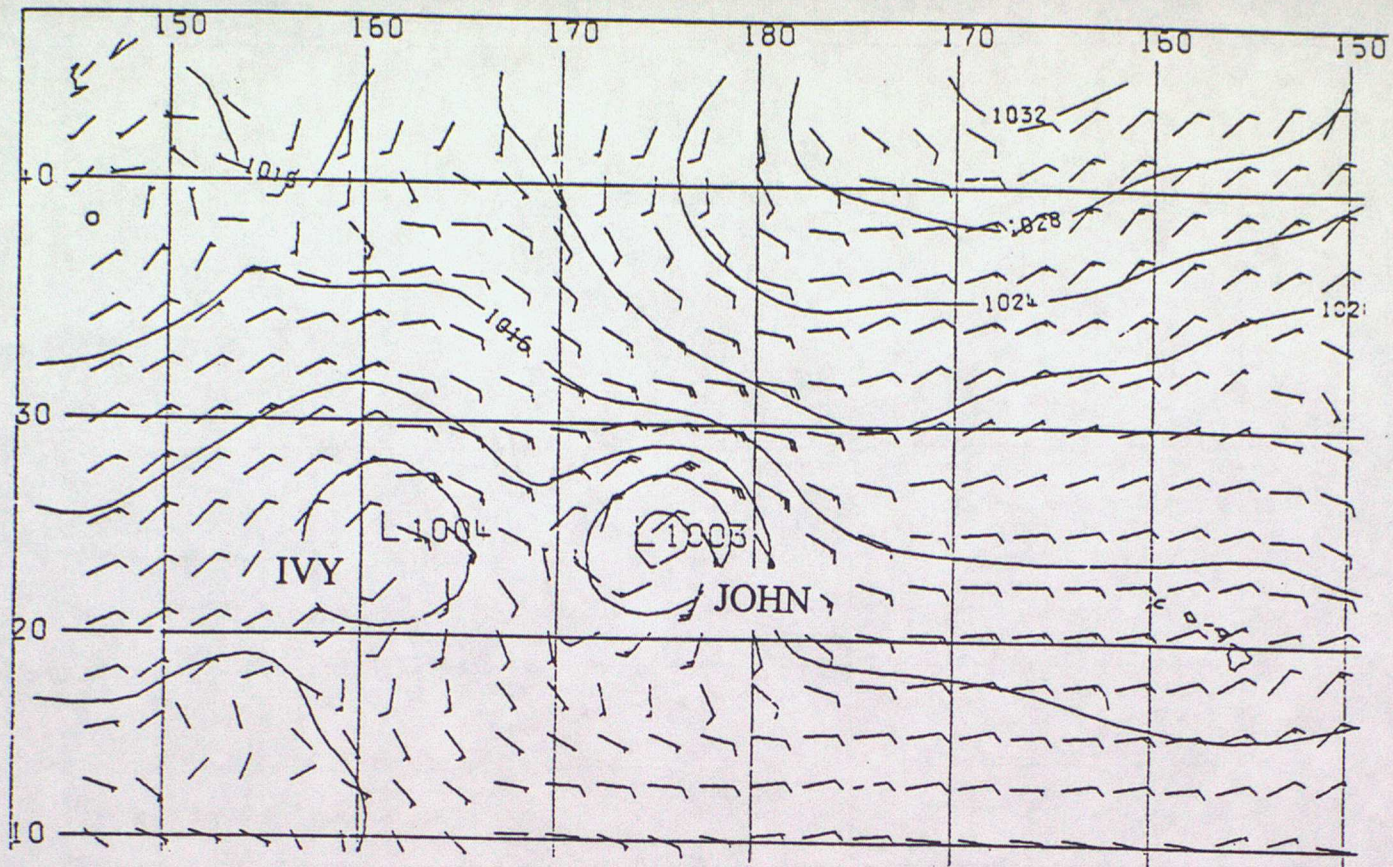


Figure 9(a)
OP analysis for TCs John and Ivy, DT 12UTC 29.08.94

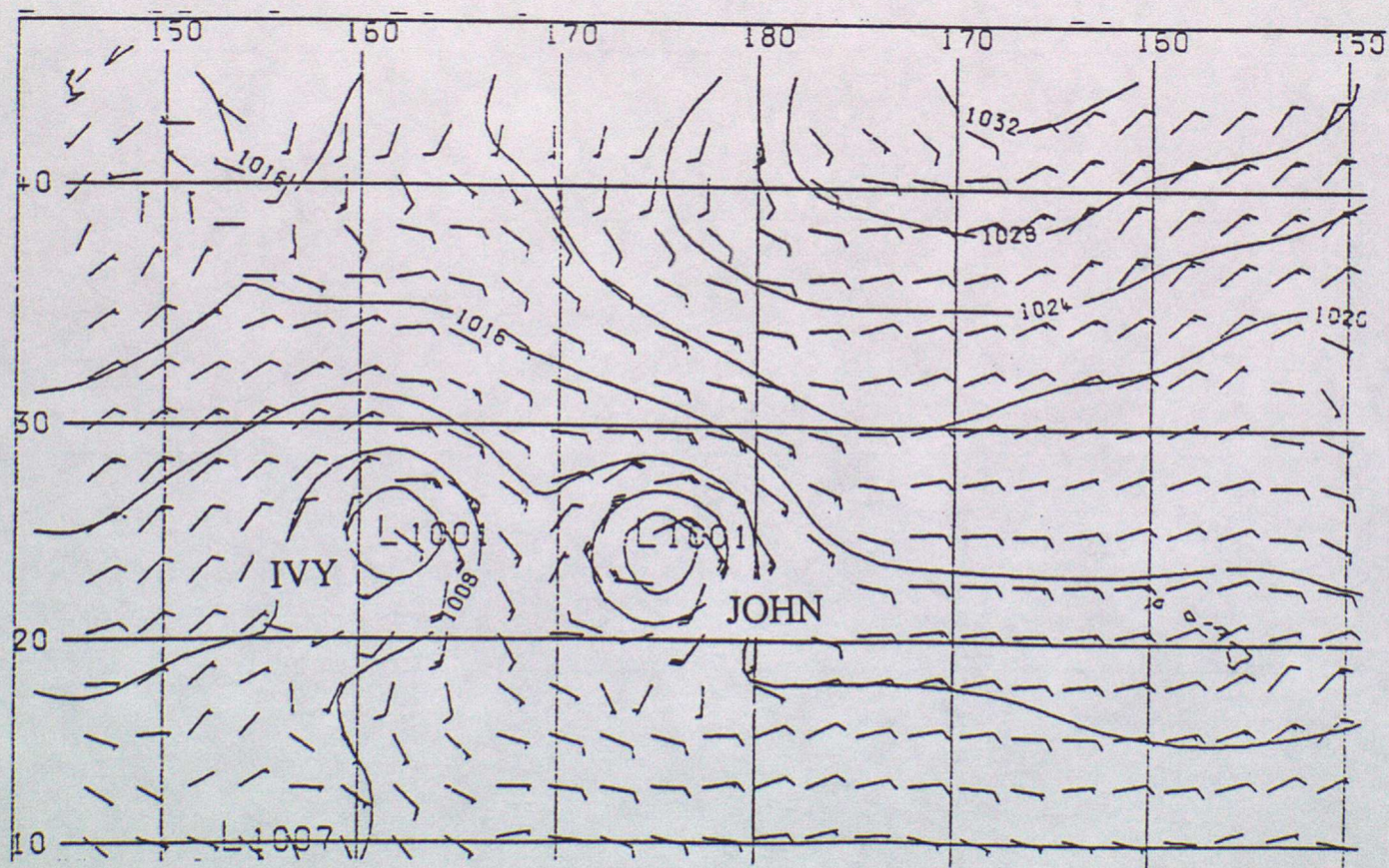


Figure 9(b)
PS analysis for TCs John and Ivy, DT 12UTC 29.08.94

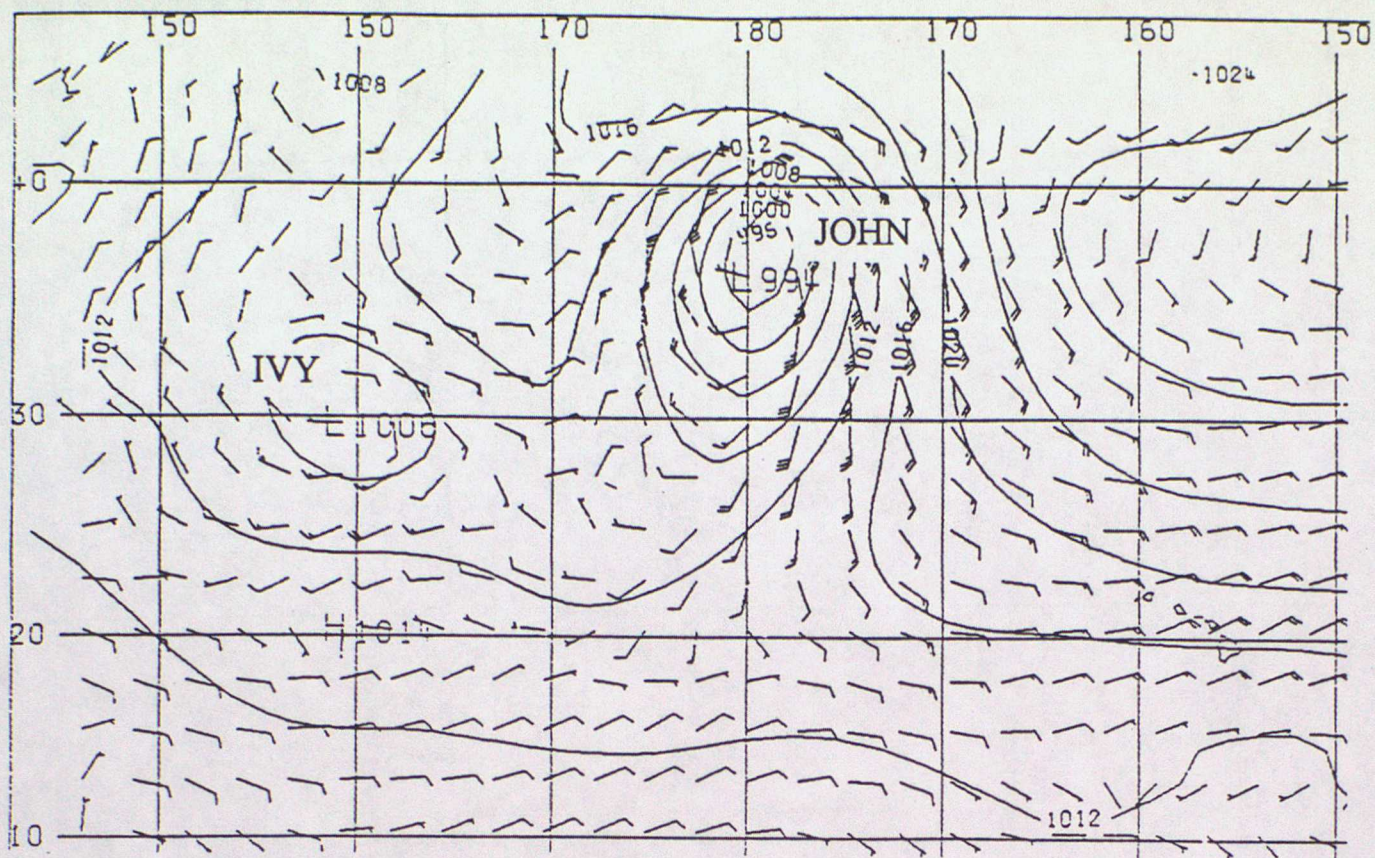


Figure 10(a)
OP T+120 Forecast for TCs John and Ivy, DT 12UTC 29.08.94

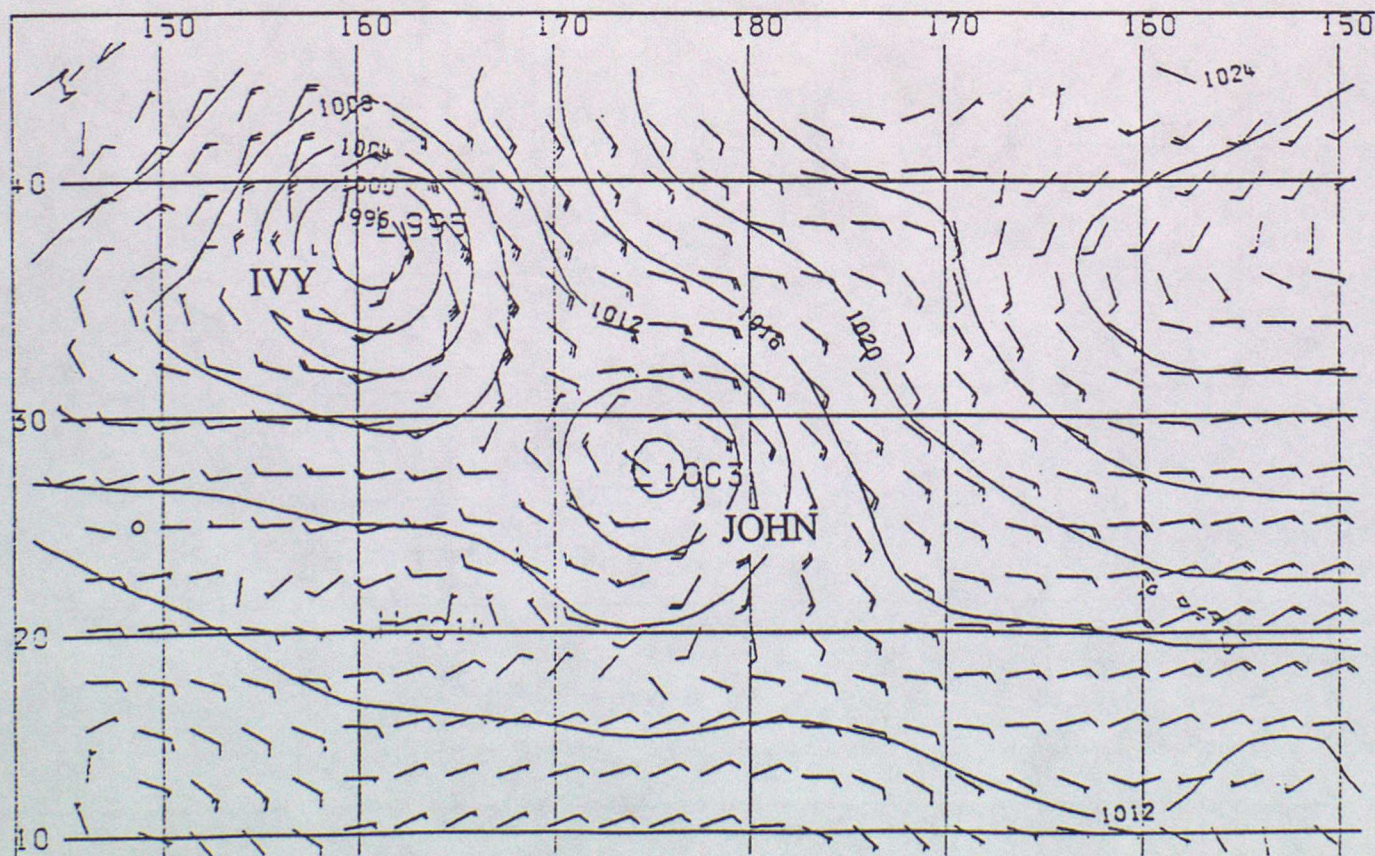


Figure 10(b)
PS T+120 Forecast for TCs John and Ivy, DT 12UTC 29.08.94

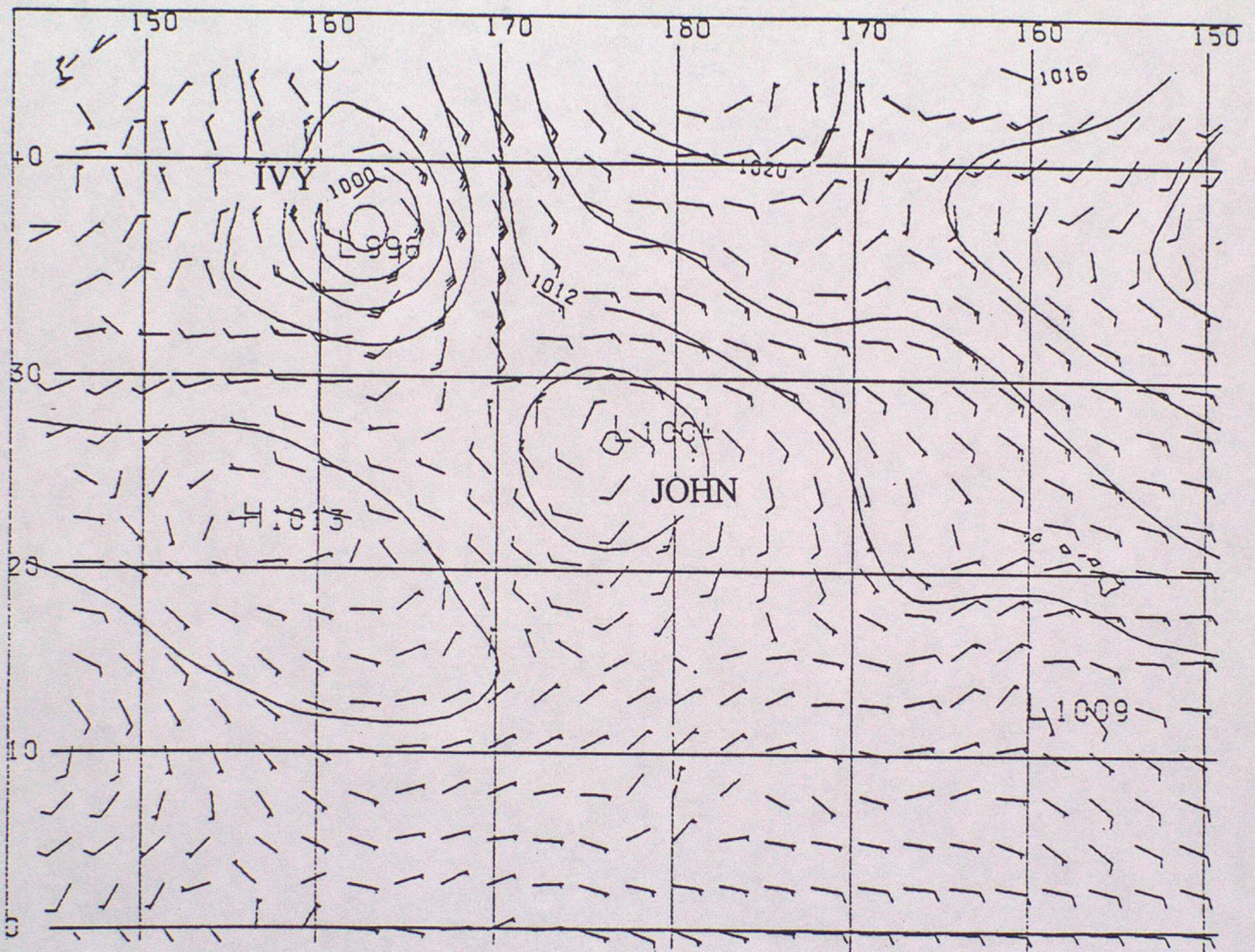


Figure 11
Verifying Analysis for TCs John and Ivy, DT 12UTC 03.09.94

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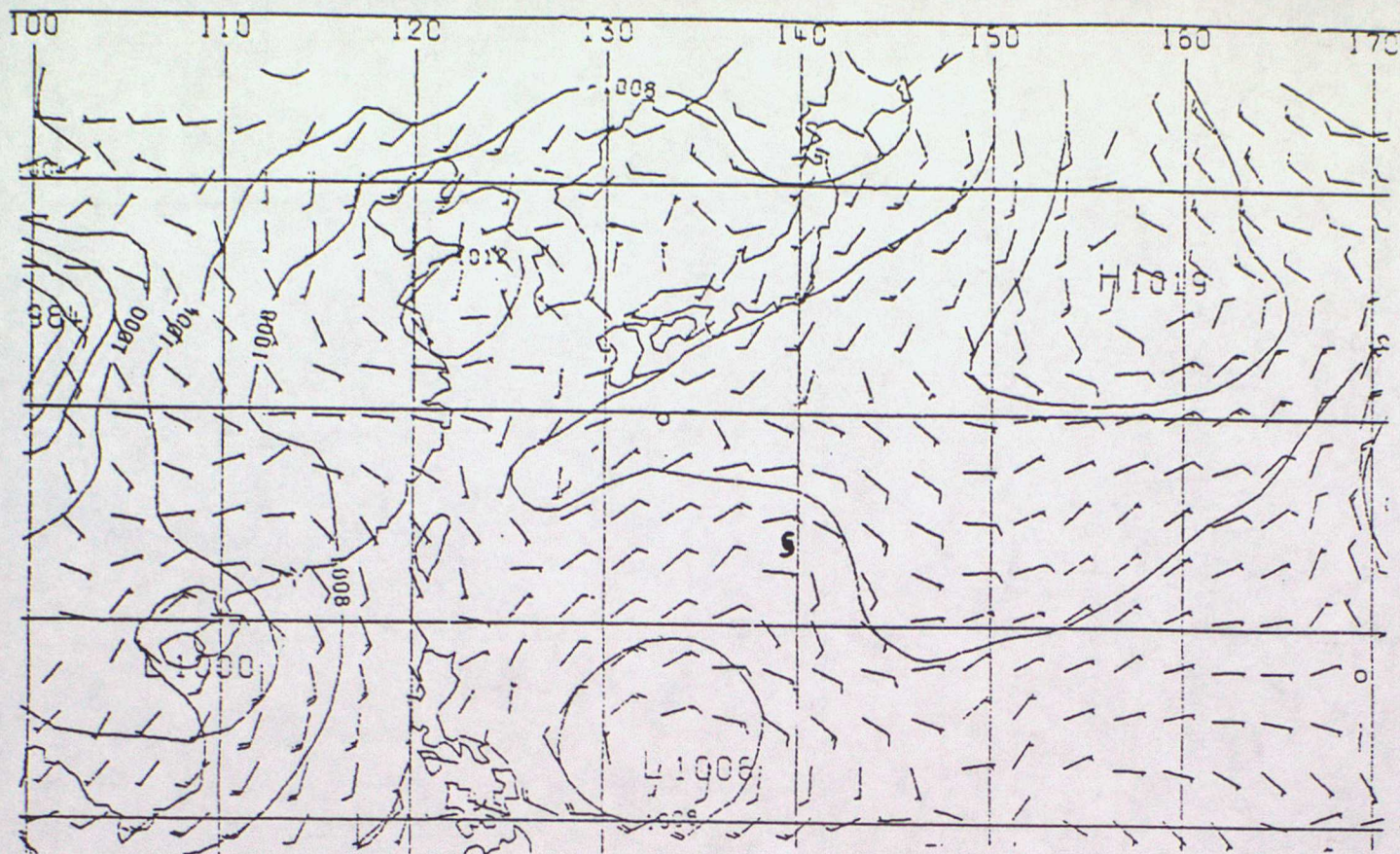


Figure 12(a)
OP Analysis for TC Kinna, DT 12UTC 06.09.94

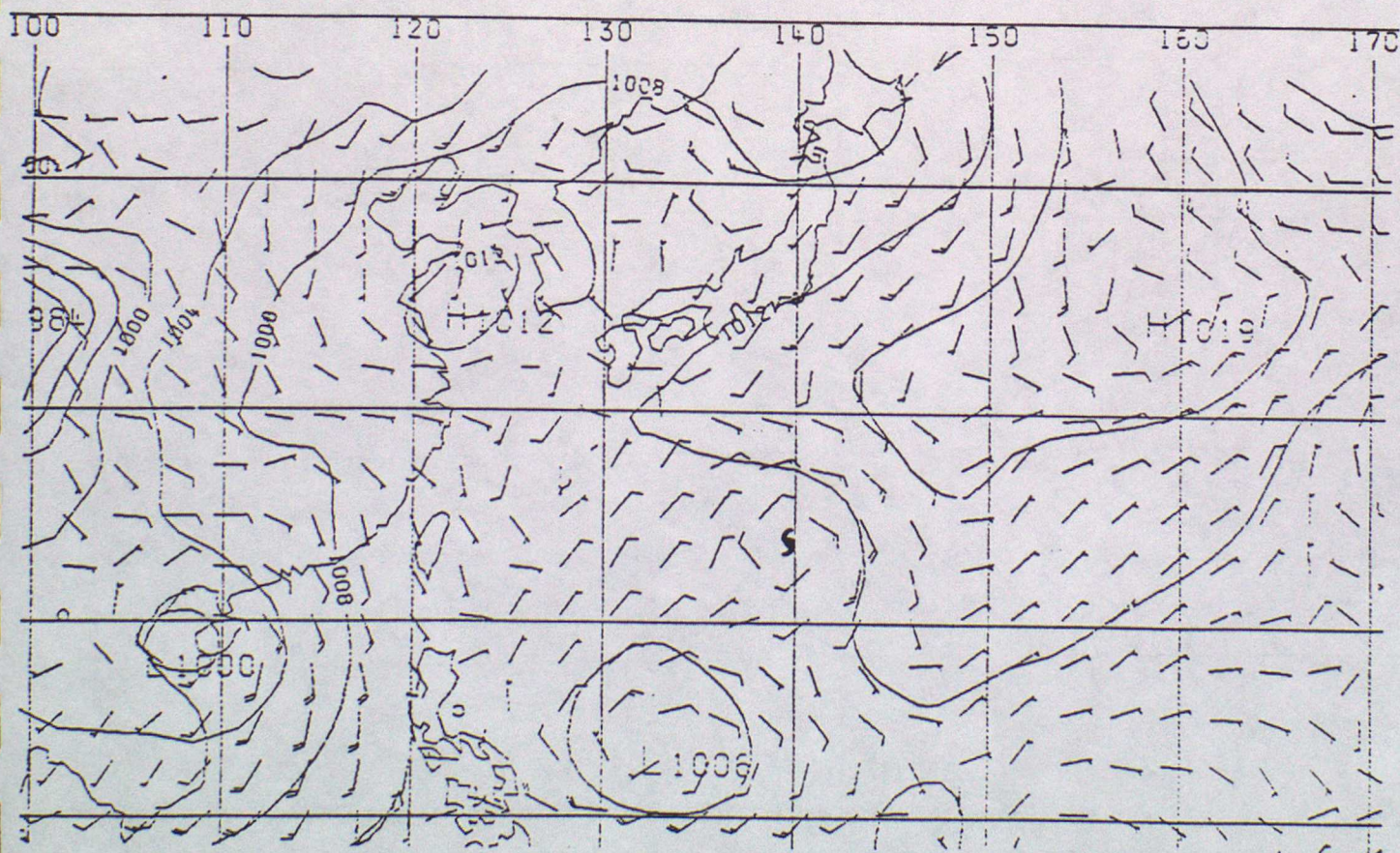


Figure 12(b)
PS Analysis for TC Kinna, DT 12UTC 06.09.94

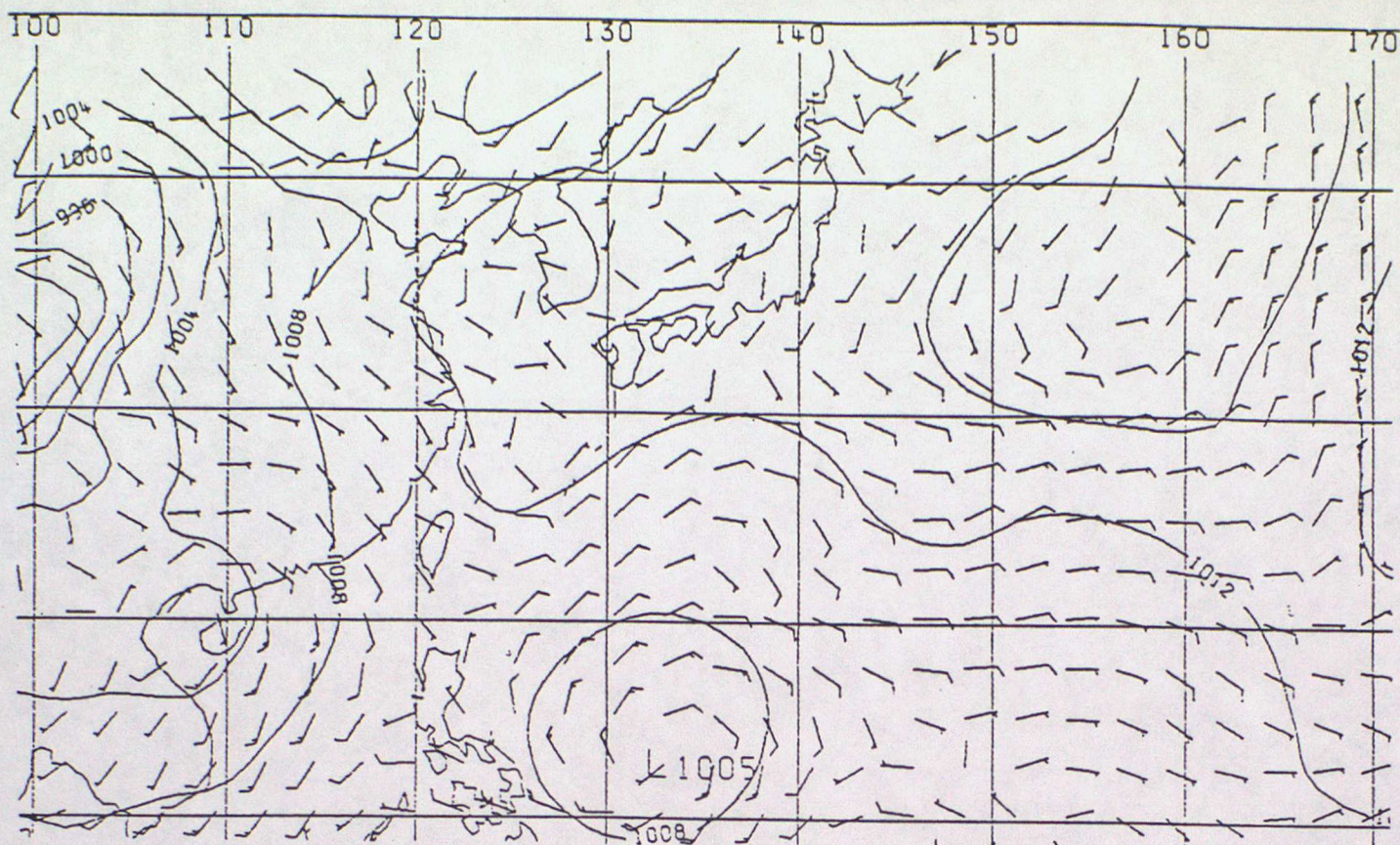


Figure 13(a)
OP T+24 Forecast for TC Kinna, DT 12UTC 06.09.94

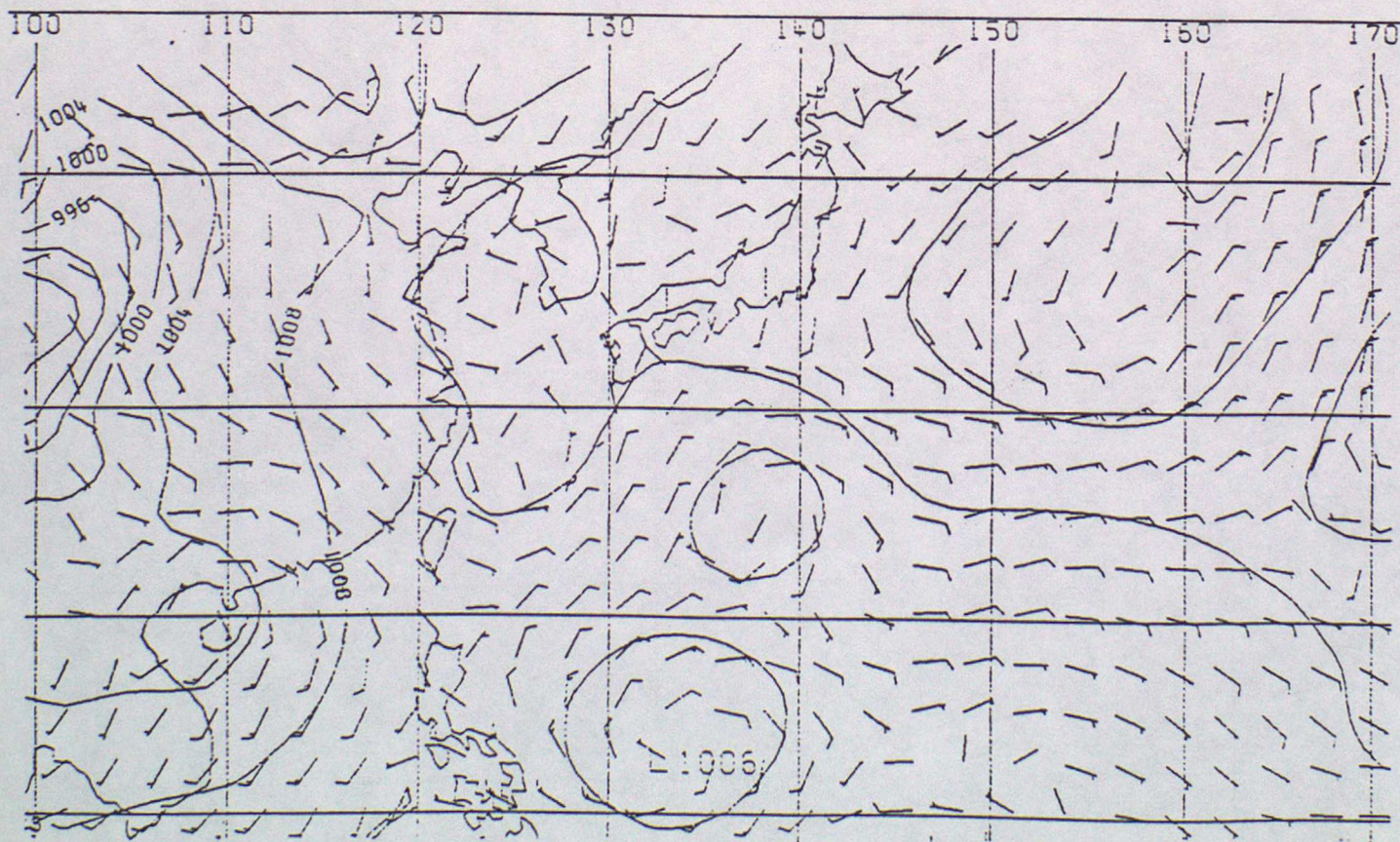


Figure 13(b)
PS T+24 Forecast for TC Kinna, DT 12UTC 06.09.94

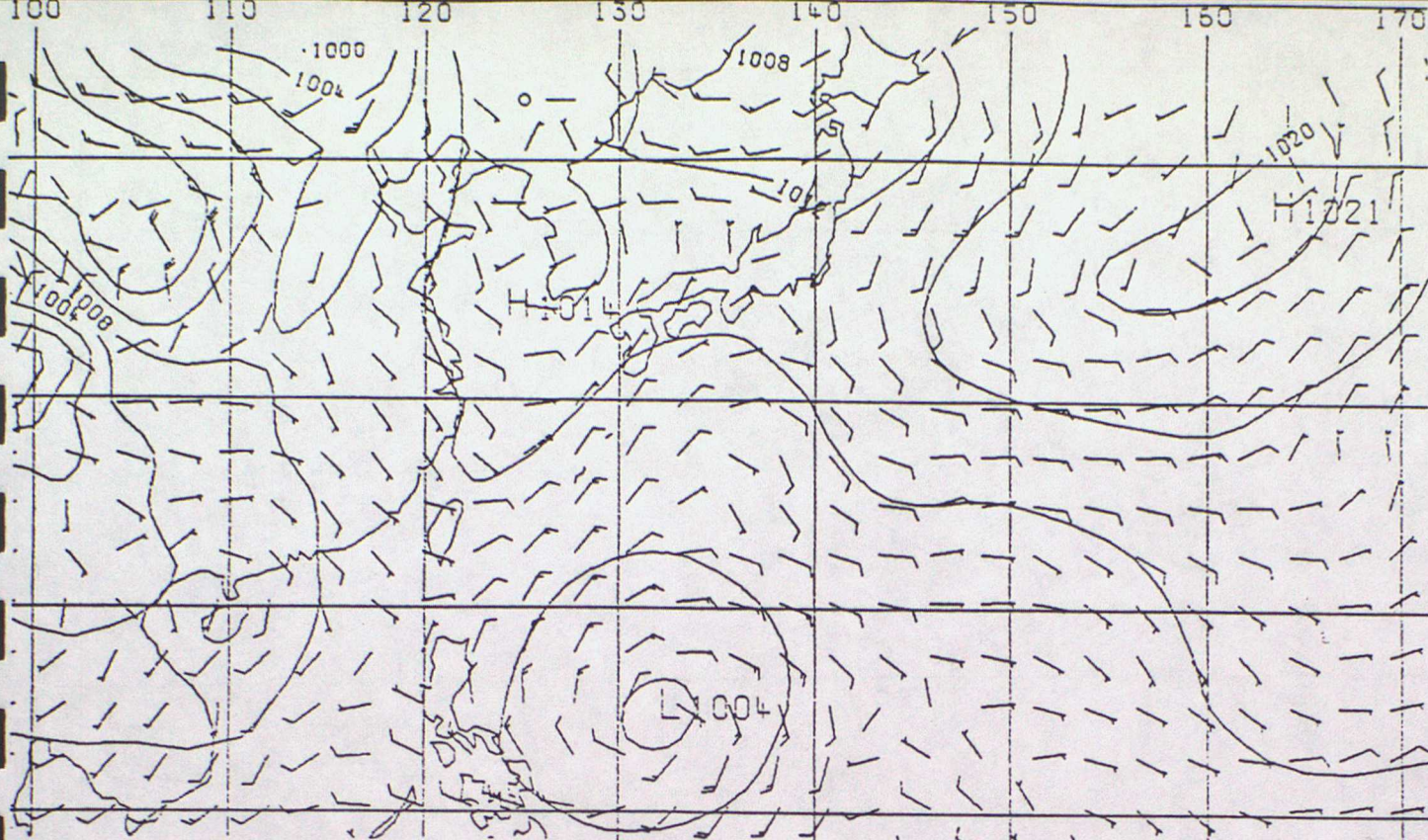


Figure 14(a)
OP T+48 Forecast for TC Kinna, DT 12UTC 06.09.94

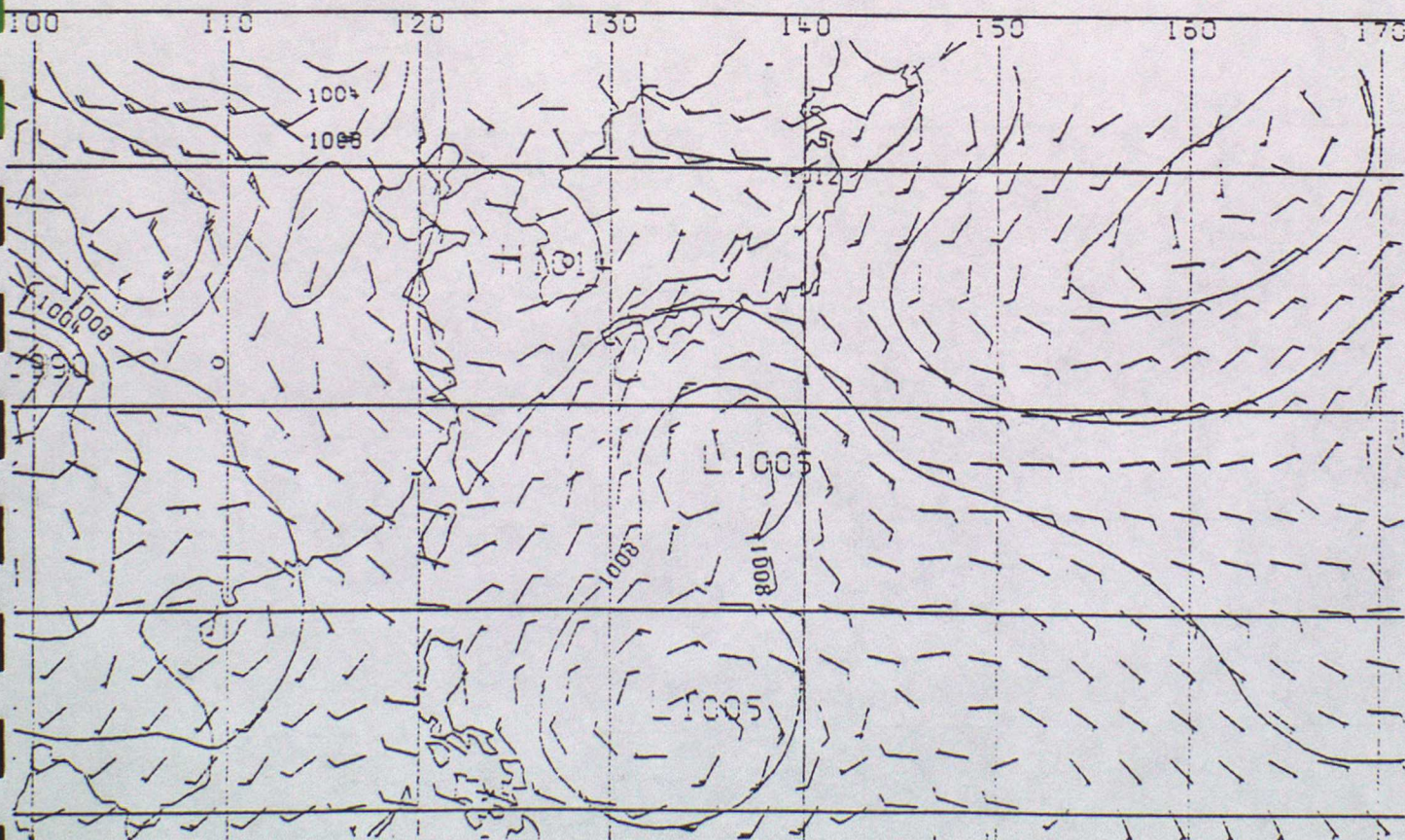


Figure 14(b)
PS T+48 Forecast for TC Kinna, DT 12UTC 06.09.94

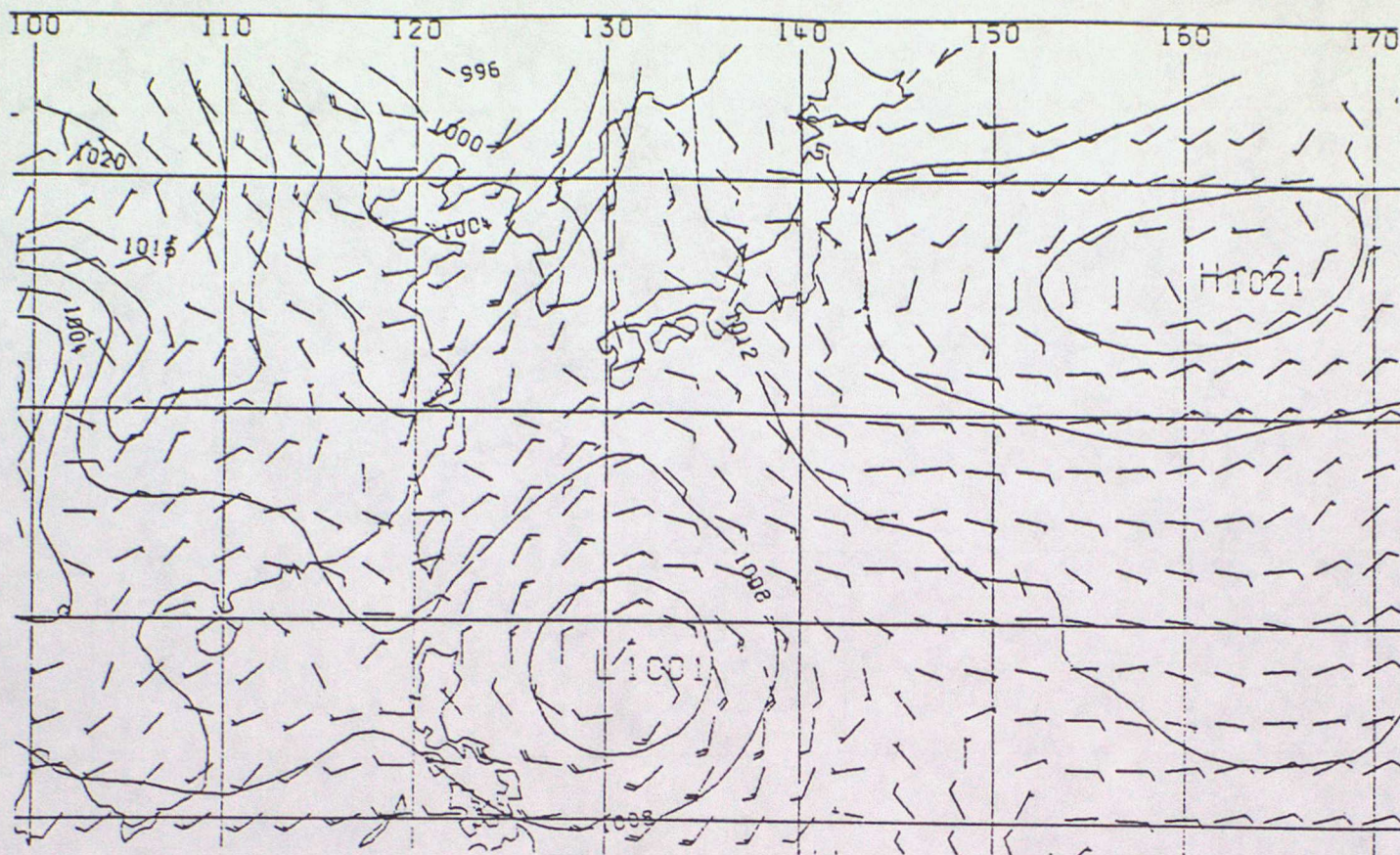


Figure 15(a)
OP T+72 Forecast for TC Kinna, DT 12UTC 06.09.94

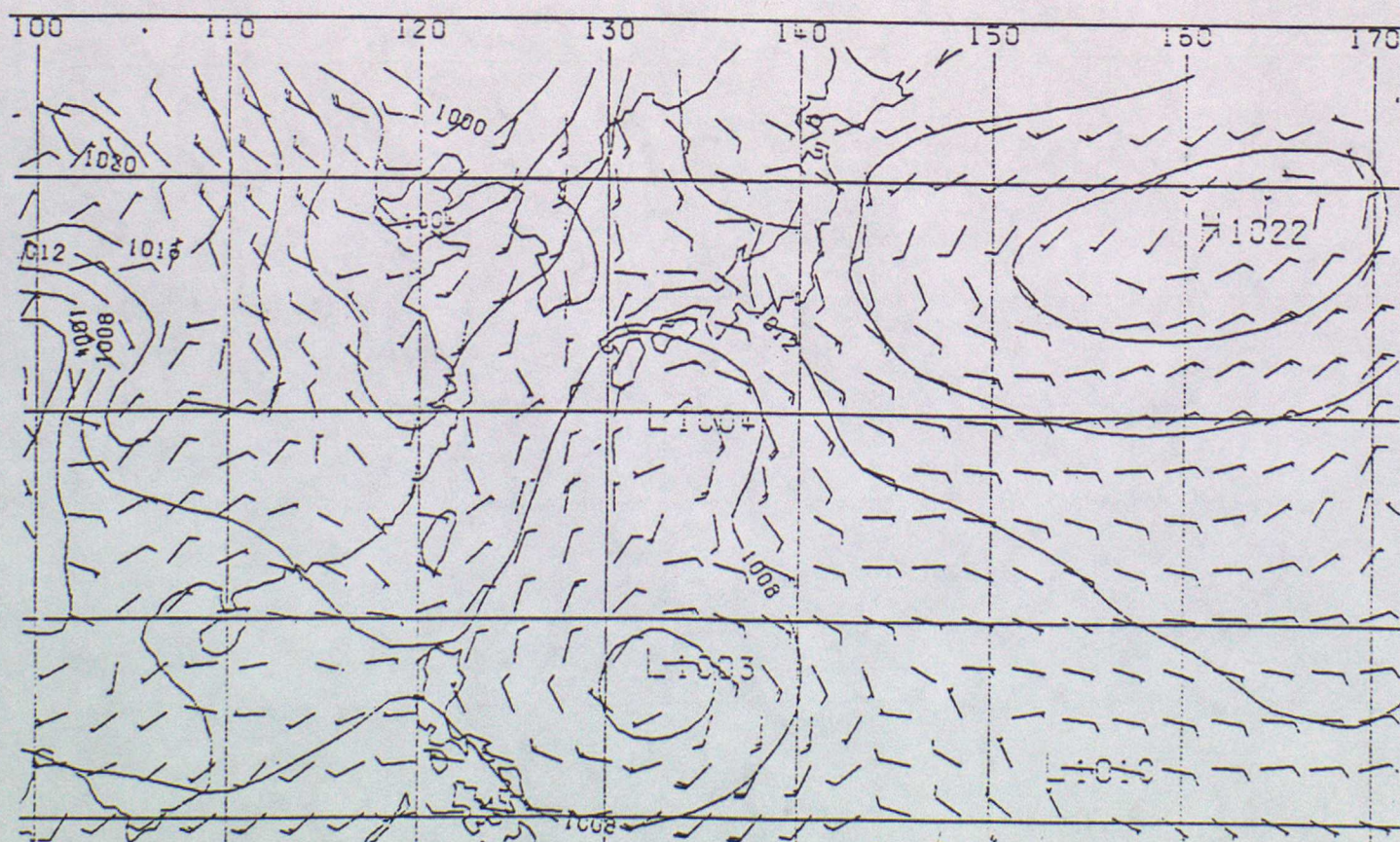


Figure 15(b)
PS T+72 Forecast for TC Kinna, DT 12UTC 06.09.94

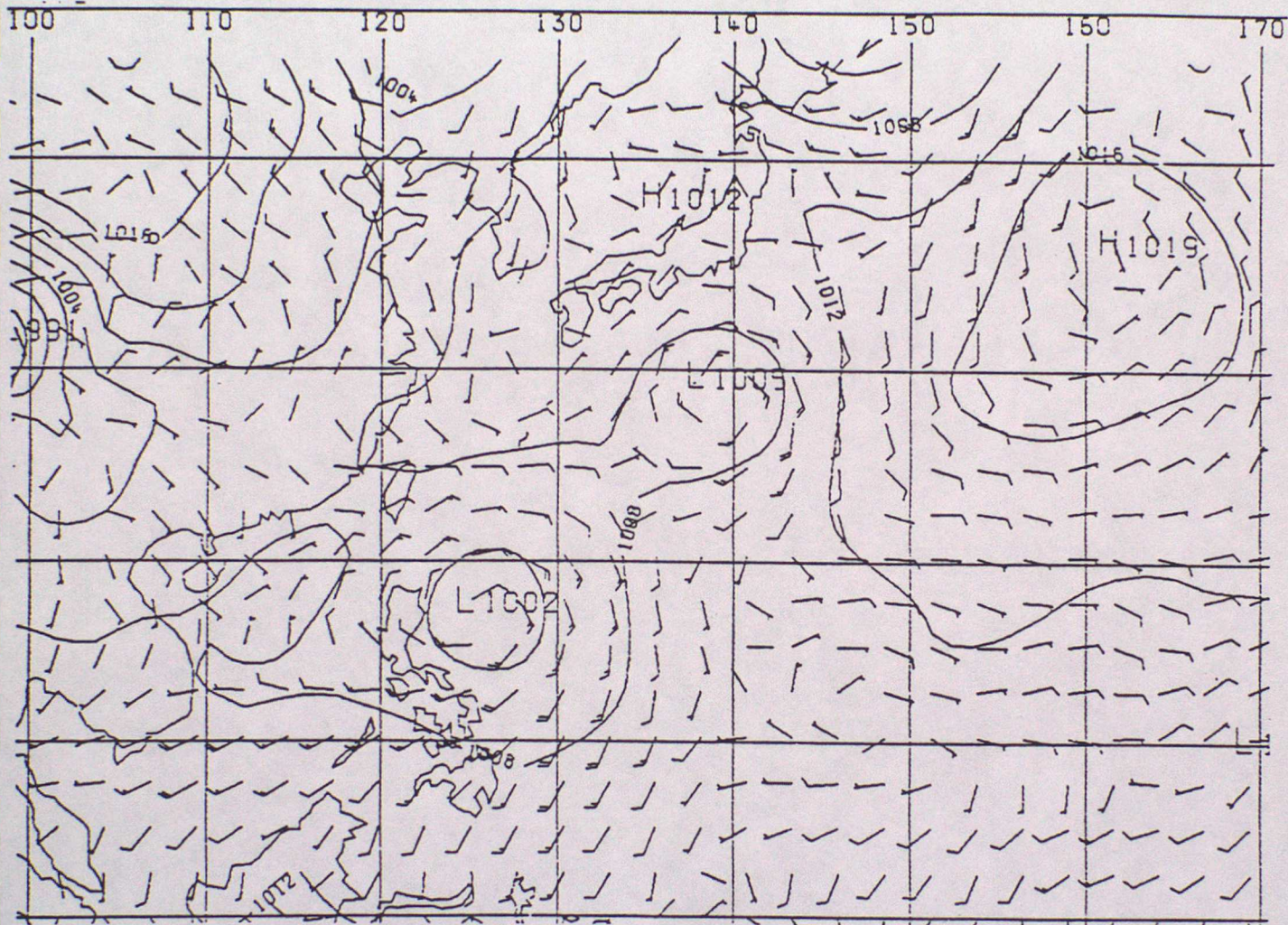


Figure 16
Verifying Analysis for TC Kinna, DT 12UTC 09.09.94